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## FREEDOM IN DEMOCRACY

SCIENCE, like British democracy, as Mr. Alderton Pink emphasizes in his stimulating little book, "The Challenge to Democracy"*, has grown up in association with religious freedom, from which sprang freedom of thought, of the Press, of teaching, of assembly—of all that we understand as cultural freedom—as well as economic freedom, though he might well have added that neither the implications nor the responsibilities of even comparative economic freedom appear to be appreciated. The issue between science or democracy itself and any kind of authoritarianism turns on the principle that the spiritual life of the individual is a region in which the State is not competent to interfere; to that extent the control of science by any outside body would eventually strangle science. In maintaining its autonomy science can play a decisive part in preserving such freedom as man has gained hitherto, and even help to enlarge it. But to do this, science must enlarge its conceptions of truth and clarify its conceptions as to the area of liberty. Such books as Prof. F. A. Hayek's "The Road to Serfdom" may conceivably have hindered rather than helped the fundamental thinking on this point that is a primary need, and Mr. Alderton Pink's chapters are by contrast a welcome stimulus. Provided cultural freedom is preserved, the democratic State is not undermining its own principles by undertaking the control of economic affairs. We must, it is true, recognize that the traditional liberty of the individual will be affected to a considerable extent, but the present alternative to serfdom is surely a system of public control under which lesser liberties are sacrificed in order to secure the greater.

The danger to which Prof. Hayek has directed attention must nevertheless not be belittled, and it is essential that the community as a whole be allowed to decide to what extent planning operations are to be allowed to encroach on individual liberties. That is as true of planning in the scientific field as in the wider field; but the scientific community must decide its own limitations, and the danger of outside control will disappear as the education of the whole community advances. We need a re-statement of the democratic principles of liberty of thought and expression. While we must preserve at any cost the freedom to publish in all sincerity the political, the artistic or the religious faith we hold, and to persuade others to accept that faith; the freedom to pursue research into any branch of human knowledge for the advance of science and scholarship; and the freedom to give expression to thought and feeling for the purposes of art, the governing motive cannot be disregarded. The freedom we guarantee must be freedom to act with a worthy purpose.

Mr. Pink develops his argument here with reference to the dangers attendant on some of the abuses of cinema and Press, and he argues that public supervision can be combined with genuine professional freedom and independence. The particular methods of securing such a balance have to be worked out by

* The Challenge to Democracy. By M. A. Pink. Pp. 118. (London: Faber and Faber, 1946.) 10s. 6d.

the democratic communities if they are to promote a healthy cultural life, and this is one of the problems that confronts the scientific community at the present time. Its complexity is well illustrated by the discussion provoked by Sir Robert Robinson's recent commendation, in his anniversary address to the Royal Society, in regard to the independence of the universities and unfettered freedom of research, and the refusal of many universities to accept theses that cannot be published.

What has to be recognized in this matter is that the positive government which is implied in a social security State and in conditions of full employment is not only bound to curtail the economic freedom of the individual to some extent; but it also involves obligations on the part of the worker, as well as of the employer and the State. Mobility of labour and abrogation of the right to withhold labour are within reasonable limits part of the price which has to be paid for social security, with all its implications for cultural freedom; and unless that price is paid, social security and much with it will collapse.

Science cannot be pursued entirely regardless of the material needs of mankind. That future depends rather on the man of science helping the community in which he works to understand his primary loyalty to the search for truth, the method by which he secures his results and the price which has to be paid for them; and in co-operating with the community in the defence of the freedom of the other cultural activities of mankind.

That, however, is only part of science's contribution to the defence of freedom and of the evolution of a new world order. An equally important contribution is that which Dr. G. H. Monrad-Krohn has indicated in his address "*Homo sapiens* and the Peace Problem: a Plea for a more Comprehensive Survey"*. Before we build a new world order that will ensure international peace, we must know very much more about the difficult country across which the road to peace must be laid. We must understand not merely the ethical demands which an international society makes, but also a great deal more about the psychological peculiarities of mass mentality that constitute so serious a threat to a rational order.

Dr. Monrad-Krohn sets forth the contribution which psychology, and especially social psychology, has to make. He urges that institutes should be created for the study of problems in social psychology, with the dual purpose of research and the exposition of its results. Nor would he confine the study of social psychology to the universities: it should begin in the schools and should be obligatory for all politicians, school-teachers and journalists. He thinks that the leading people in broadcasting and in the cinematograph world should have a knowledge of mass psychology, so as to enable them to realize their great responsibilities. His attitude to the Press, broadcasting and the cinema, advocating full freedom under full responsibility, is similar to that of Mr. Alderton Pink. He is under no illusions as to the pace of advance. Social psychology, although of steadily increasing importance, is still in its youth; but this highly stimulating paper makes constructive suggestions for a programme to avert the great dangers which at present confront us, and to repair the moral deterioration which any war inevitably entails.

The plea for attention to psychological as well as technical factors in the rebuilding of the world is not to be set lightly on one side; and Dr. Monrad-Krohn is also fully aware that while this educational campaign is proceeding, not merely binding international legal arrangement but also a heavily armed international police force and a very close control of armaments everywhere will be essential. But he does point a way forward that must be explored, and he indicates a contribution which the man of science can, as citizen, do something to promote.

What needs to be remembered is that the elimination of war as a means of dealing with international disputes and the development of a world order, as indeed of an ordered State, demand not merely improvements in the efficiency of government, but also a positive contribution from the individual citizen in the form of the discharge of certain responsibilities. Social psychology may come indeed to make a vital contribution to that intelligence system which is so essential an element in the integration of national, local and sectional interests into policy and a plan of action conceived and accepted by all. But a new spirit is required to vitalize the body politic—a unifying purpose as well as a habit of responsible criticism—if men and women are to be capable of accepting the sacrifices, at every cultural, social or economic level, which a properly planned democratic order must continually demand in the interests of the whole.

While his approach is different, that is also a main theme of Mr. W. A. Gauld's "Man, Nature and Time"*. He insists that man rather than Nature gives direction and purpose in history, and that the world as we experience it to-day is a man-made world to a much greater degree than we allow; then he challenges outright much of the pessimistic thought to-day and the tendency to drift. He presents a picture of a dynamic world, emphasizing its complexity and interrelations in much the same way that Dr. Barlow did in "The Discipline of Peace", rejecting the physical determinism which accounts for events by conditions. It is a challenge to thought as well as to action, and although he points less clearly to the moral factors than Mr. Pink, Mr. Gauld is equally convinced of the importance of spiritual values and the necessity for a moral basis for the world order which he sees as in the nature of things and not merely as an idealist concept.

There is a realism and a confidence in this modest introduction to world study which are invigorating, and will be needed in the task of education to which Mr. Gauld also summons us. His book is indeed more challenging than Prof. Herman Finer's "The Future of Government"†, for it is only in the last

* *Homo sapiens* and the Peace Problem: a Plea for a more Comprehensive Survey. By Dr. G. H. Monrad-Krohn. Pp. iv+16. (London: H. K. Lewis and Co., Ltd., 1946.) 2s. 6d. net.

* Man, Nature and Time: an Introduction to World Study. By William Alexander Gauld. Pp. x+291. (London: G. Bell and Sons, Ltd., 1946.) 10s. 6d. net.

† The Future of Government: being a Continuation of the "Theory and Practice of Modern Government". By Herman Finer. Pp. ix+198. (London: Methuen and Co., Ltd., 1946.) 10s. 6d. net.

chapter that Prof. Finer rises above a pedestrian chronicle of events and surveys the future task of democracy. In that chapter, however, he does something to justify the title of his book, and comments which elsewhere are overlaid with detail are seen in truer perspective, even if there is little that is new. Prof. Finer, no less than Pink and Gauld, recognizes the influence on the present situation of deep individual complexities and insecurity regarding spiritual values; and he sees too that the threat to freedom comes, not only from dictators afraid of its consequences, but also from the sharpening of control by each nation over its scientific and technical community by such means as the Official Secrets Act, and pledges to an international organisation permitting an inspectorate full access to all plants. He voices explicitly the continuing anxiety whether the basic liberties, freedom of expression and debate, of change of government, of association and of impartial judgment before the courts can stand up against the high degree of organisation, self-control and the internal controls involved in national and international organisation.

Prof. Finer has a clear view of what is at stake, both for science itself and for the democratic society in which it can best flourish, and the price to be paid is set down fairly. It is an unending task in science as well as in government to protect the open way for the communications of the gifted, and equally to maintain the proper conditions by which the multitude's reflexion upon them is promoted; and scientific men are at last coming to appreciate the dangers which have followed the neglect of the latter task. The relation of knowledge to power is an unending and ever-changing problem, and grows the more intimate as the knowledge needed for leadership, direction and decision in the world grows more complex. Effective democratic government, Prof. Finer observes, requires the interplay of the general body of citizens and the statesmen; not the exclusion of eminence but its contributive uses; and events at home and abroad are testifying to the truth of his further comment that the unity of a dynamic society is a product not simply of mass but of representative creativeness at a responsible centre, and that the fellowship which marks a nation in its progress is in part the product of men at the responsible summit who can relate the needs of the whole social situation to the fragmentary contending wants of millions of aggressive individuals.

Planning and organisation there must be in government, no less than in science, if chaos and waste are not to reign supreme. But beyond this there must be that vision, that sense of purpose, of moral and spiritual values that will give unity to its activities and draw together in harmony and fellowship the myriad units who pursue these activities or whose wants are satisfied by them. The major question for our time is whether this generation has the courage, imagination and will to master the modern social techniques and to guide them in the right direction, and on this point Prof. Finer is silent. We turn, therefore, to Dr. Monrad-Krohn, the late Prof. K. Mannheim and Mr. Alderton Pink for guidance and suggestions on developing the moral qualities of the peoples, and the changed attitude to education—and especially to adult education—which can alone cure the social diseases so evident and so widespread to-day. These can provide the ethical foundations for the new institutions and instruments of government, regional and functional, national and international, which mankind must evolve to safeguard its great cultural heritage. They can ensure the greater freedom of mind and culture, of communication and utterance in which alone science and the arts can flourish, and which to-day are so sinisterly threatened by the very powers which science has put into the hands of men to command.

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## NUCLEAR EXPLOSIVES, NUCLEAR POWER AND WORLD AFFAIRS

### One World or None

Edited by Dexter Masters and Katharine Way. (Whittlesey House Publication.) Pp. xi+79. (New York and London: McGraw-Hill Book Co., Inc., 1946.) 5*s*.

THE atomic bomb is one great cause of political uncertainty in the world to-day. Although the difficulty of reaching a satisfactory solution of the problem is largely confined to the relationship between the United States, the great Power which possesses the bomb, and the U.S.S.R., the other great Power of to-day which does not yet have stocks of the revolutionary weapon, the significance of the new discoveries is probably greatest of all for Great Britain and the Commonwealth. The concentration of industry and population in the cities of the British Isles, the island isolation which has been such an asset in the past, but which now prevents adequate dispersal or effective interception of fast aircraft, our dependence on sea communications and the very nature of our climate which offers cover to the raider, all combine to make us more vulnerable than any other industrial country. At the same time, the probability that atomic energy will provide abundant power which could counteract many of the disabilities of large parts of the Commonwealth, which are ill-endowed by Nature, means that we have a special positive stake in the elimination of the war-like uses of atomic energy and rapid development of all its peaceful applications.

The collection of essays in the book under review represents an early analysis of the situation from the point of view of American writers. The authors are some of the best-known men of our day in physical science, in military arts and in constructive journalism. Some of the articles are brilliantly written, and reveal the grave concern for the future of civilization and of science which is felt by all men whose thoughts go beyond the barriers of nationalism. The foreword is by that great scientific humanitarian, Niels Bohr, who, in the days before the bomb was dropped, taught all who worked with him how to think constructively about the political problems which use of the bomb would engender. Subsequent events have shown clearly how right he was and how sad it is that his ideas were ignored.

The technical facts about the bomb and its control and the peaceful possibilities of atomic energy are discussed by such brilliant scientific writers as Oppenheimer, Ridenour, Condon, Morrison, Einstein,

Urey and Bethe, while General Arnold shows why, despite the claims of some interested parties to the contrary, the bomb and its future possibilities do make no nsense of great navies, great armies and air forces. It is clear that if preparation for war is to continue to be the principal peace-time preoccupation of men, the future lies with small highly trained specialist corps to disperse the new agents of destruction and to do what little is possible to intercept them and to counter their effects.

Almost all these writings can be translated readily to refer to the British Commonwealth. Much of the wisdom contained in them has been incorporated in the Lilienthal–Baruch plan for control of atomic energy, which is now under consideration by the United Nations. Since the end of the War, Oppenheimer, Urey and others in the United States have devoted their whole time to consideration of these problems, and behind anything constructive which has emerged lies the determination and great understanding of these men. Despite the greater urgency of the problem for us in Britain, no one here has emulated this achievement, probably largely because public activity by a man of science in Great Britain brands him at once as an 'awkward fellow'. During his recent visit Prof. Urey remarked that "there is a comparative lack of a sense of urgency here", and perusal of these articles from the United States may help to awaken a more vital interest.

In the absence of corresponding British documents, the U.S. "Smyth Report" and "One World or None" form companion books of information for all men of science who have feelings of responsibility for the effects of their work on world affairs.

M. L. Oliphant

## RENEWAL OF A CLASSIC

### The Common Sense of the Exact Sciences

By William Kingdon Clifford. Edited and with a Preface by Karl Pearson. Newly edited and with an Introduction by James R. Newman. Pp. lxvi+250. (New York: Alfred A. Knopf; London: Sigma Books, Ltd., 1946.) 15*s*. net.

THIS volume is the product of many minds. Clifford left the manuscript of "The Common Sense of the Exact Sciences" in a very incomplete state at his death in 1879, and the work of editing it for publication was entrusted to Prof. R. C. Rowe, who himself died in 1884 with his task unfinished. It was then taken in hand by Prof. Karl Pearson, and eventually appeared in 1885 and passed through various editions. An American publisher has now reprinted it, with a preface by Earl Russell and a 48-page introduction by Mr. James R. Newman, who has also added many footnotes.

The book has been so well known for generations —Russell tells us how he read it "with passionate interest" nearly sixty years ago—that a description in detail would be superfluous; all that is called for seems to be some comments on its general character and on the contributions of its latest editor.

Perhaps the only criticism that might be made of the original work was the disparity between different chapters, as regards difficulty of comprehension. The early part (that a sum is independent of the order of adding, a product is independent of the order of multiplying, and so forth) can be understood by a young child, while the treatment of, for example, the curvature of space, which comes later (though the ideas are explained with wonderful lucidity), calls for considerable intellectual power and some maturity of mathematical knowledge (indeed, I knew personally a university professor of natural philosophy of the generation next above mine, who to the day of his death refused to believe in the possibility of non-Euclidean geometry). The reader is liable to be either bored by the laboured discussion of the obvious, or unable to grapple with the more advanced subjects.

The editor, Mr. Newman, has done his work well; his footnotes are admirable, and show both learning and judgment. But the situation was a difficult one; Clifford died before the modern theory of number was discovered and before his brilliant ideas of geometrizing physics had been brought to its glorious fruition by Einstein; and to graft notions of these theories on his book was scarcely possible without complete re-writing. The effect of trying to do it is sometimes rather as if an explanation of the multiplication-table had notes warning the infant reader that the multiplication of quaternions is non-commutative.

Edmund Whittaker

## PHILOSOPHERS AND HISTORIANS

### Leviathan or the Matter, Forme and Power of a Commonwealth, Ecclesiasticall and Civil

By Thomas Hobbes. Edited with an Introduction by Michael Oakeshott. Pp. lxvii+468. (Oxford: Basil Blackwell, 1946.) 8*s*. 6*d*. net.

### The Second Treatise of Civil Government, and a Letter concerning Toleration

By John Locke. Edited with an Introduction by J. W. Gough. Pp. xxxix+165. (Oxford: Basil Blackwell, 1946.) 8*s*. 6*d*. net.

### On Liberty and Considerations on Representative Government

By J. S. Mill. Edited with an Introduction by R. B. McCallum. Pp. lix+324. (Oxford: Basil Blackwell, 1946.) 8*s*. 6*d*. net.

### Prophets and Peoples

Studies in Nineteenth Century Nationalism. By Prof. Hans Kohn. Pp. vii+213. (New York: The Macmillan Company, 1946.) 10*s*. 6*d*. net.

### Politics and Morals

By Benedetto Croce. Translated from the Italian by Salvatore J. Castiglione. Pp. 138. (London: George Allen and Unwin, Ltd., 1946.) 8*s*. 6*d*. net.

THE seventeenth century, with its forcing ground of ideas during the Civil War and Commonwealth, can now, more clearly than ever, be seen as one of the decisive periods of modern history for England, and, through England, for Europe. The English Revolution, like its successors in America, France and Russia, which drew inspiration from it, has left an ineffaceable mark on world history. It is well, then, that at this time, when accusations of reaction and stagnation are in the air, we should be reminded of the pioneering work of the seventeenth century that has ensured three centuries of the steady development of what we recognize to-day as the British conception of democracy. One of the most daring and original minds of the revolutionary era was that of the philosopher, Thomas Hobbes, whose classic and long hotly debated "Leviathan" has now been re-issued for the student, with a striking intro-

ductory essay by Mr. Michael Oakeshott. It appears, properly enough, with John Locke's equally famous, and more obviously influential, "Civil Government", edited by Mr. J. W. Gough, and with John Stuart Mill's Victorian classics, "On Liberty" and "Representative Government", introduced by Mr. R. B. McCallum, the three volumes being the first of a new series of "Political Texts" which should win a high place in the esteem of the student of political philosophy.

Hobbes has so often been dismissed in recent times as an early "Fascist" that it is stimulating to find Mr. Oakeshott insisting on his individualism and on his opposition to absolutism and arbitrary rule: "Nor is . . . the Leviathan a designed destruction of the individual; it is, in fact, the *minimum* condition of any settled society among individuals. . . . Hobbes, without being himself a liberal, had in him more of the philosophy of liberalism than most of its professed defenders." To this view may be opposed a sentence from Dr. G. P. Gooch's British Academy lecture on Hobbes, delivered in 1940: "Hobbes was the foe of the idealism, the individualism, and the method of compromise which have given Western civilisation its colour and shape". With Mr. Oakeshott's clear and readable text before him, the student can form his own opinion and ponder the relevance of this undoubted masterpiece for the fundamental political and social problems of our own day. Above all, he can relish the force of Hobbes' statement, a challenge in its own day, that the State was formed for man, and not man for the State: "For by art is created that great LEVIATHAN called a COMMONWEALTH, or STATE, in Latin CIVITAS, which is but an artificial man; though of greater stature and strength than the natural, for whose protection and defence it was intended".

Locke has a less general validity; but as the apologist of the Glorious Revolution of 1688 his influence on English and American political development has been considerable, as Mr. Gough is concerned to show. "The end of government," Locke wrote, "is the good of mankind", and he drew a distinction between society and State, which Hobbes had confused, and thereby justified the English tradition of social activity apart from the State which was particularly fruitful in the nineteenth century, and created the political atmosphere in which J. S. Mill's work was conceived. "With the English-speaking peoples," says Prof. Kohn in an essay on Mill in "Prophets and Peoples", "the initiative rested with society, not with the state." Conditions have changed in eighty years, but the closing passage of "On Liberty" has still a real meaning and message: "A government cannot have too much of the kind of activity which does not impede, but aids and stimulates, individual exertion and development. The mischief begins when, instead of calling forth the activity and powers of individuals and bodies, it substitutes its own activity for theirs. . . . The worth of a State, in the long run, is the worth of the individuals composing it."

"Prophets and Peoples" is a collection of essays on various national and nationalist philosophers of the past century, Mill, Michelet, Mazzini, Treitschke and Dostoevsky. They are sound and thoughtful studies, which whet the appetite for Prof. Kohn's forthcoming study of nationalism during the period. But what is most striking as one reads the book is the change in mood and outlook as one passes from the three Western European thinkers to Treitschke and Dostoevsky: many of our recent difficulties are revealed in the contrast.

Prof. B. Croce has long been famous as the philosopher and historian of liberalism, and this most recent book, "Politics and Morals", consisting of essays written, apparently, before the War, re-states his faith in Western democracy on liberal foundations. "In the final analysis," he says, in words that recall Mill, "States are what the men who constitute them continually make them. . . . The liberal conception is not meant for the timid, the indolent and the pacifist, but wishes to interpret the aspirations and the works of courageous and patient, of belligerent and generous spirits, anxious for the advancement of mankind and aware of its toils and of its history." The emphasis, again, is on men, not institutions, and the moral is clear.

MAURICE BRUCE

## FRUIT GROWING

### Hardy Fruit Growing

By Sir Frederick Keeble and A. N. Rawes. Second edition. Pp. xi+342+21 plates. (London: Macmillan and Co., Ltd., 1946.) 20*s*. net.

THE first edition of this book appeared in 1936; it is a testament to the distinguished authors that so little change has had to be made in this new edition. A few deletions of material now out of date, a new paragraph here and there to amplify some point in the light of new knowledge, more especially in the section dealing with cultivation and manuring, and a more extensive revision of the sections on the pests and diseases of individual fruits by Messrs. Fox Wilson and Green of the Royal Horticultural Society's laboratories, are all that have been found necessary.

The avowed primary object of the book, to provide amateur and professional gardeners with a sufficient guide to enable them to grow fruit well, is admirably achieved. The first half of the book, on planting, upkeep, propagation and storing, is meant to be read and, coming from the pens of two such able writers, is most eminently readable. It contains a great amount of factual experiential teaching; the only criticism one might make is that a writer such as Sir Frederick Keeble, who possesses to such a unique degree the gift of exposition of science to the non-scientific, might have dilated more on the physiological principles underlying the practice of fruit growing. To a greater and greater extent in these days the enthusiastic amateur wants to know the 'why' as well as the 'how', and few can explain it better than Sir Frederick. Many thousands will always remember with delight his popular scientific leaders of the *Gardener's Chronicle*, and will wish that more of that easy, intimate style could have been infused into the present work.

The second part is a reference section dealing with each of the main hardy fruits in turn, discussing varieties, pests and diseases, and special points of culture. In the selections of varieties for different purposes one sees the hand of the second author, than whom few know fruit varieties better. No one would quarrel with his choices, though perhaps more of the newest varieties of outstanding merit might have been included in this second edition. A notable example is the omission of the plum variety 'Marjorie's Seedling', one of the best all-round plums for private and commercial grower alike, though admittedly not of the very first quality for dessert flavour.

The sections on the pests and diseases of the separate fruits are admirable examples of succinct information without a wasted word; perhaps the use of D.D.T. is too new and experimental as yet to be included in a text-book of this kind, though its value in the control of apple blossom weevil, to take a single example, would seem to be so great as to have called for some mention, however cautious.

The last section of the book, dealing in an introductory way only with commercial fruit growing, is disappointing. It is too brief to be of any value to the established grower, yet too detailed to be interesting to the amateur. The inclusion of some simple physiology in the first section, as we have suggested, would allow of the omission of this part without loss to the value or size of the work. In particular, there seems no reason whatever for the chapter on the very specialized subject of forcing strawberries under glass. No other fruits under glass are dealt with, so why pick out this one example?

The public to whom the book is primarily addressed will, however, find all the practical information they can want within the book, and it will stand as one of the most valuable works on the subject.

R. H. Stoughton

## BIOLOGY OF THE TREMATODA

### The Trematoda

With Special Reference to British and other European Forms. By Dr. Ben Dawes. Pp. xvi+644. (Cambridge: At the University Press, 1946.) 52*s*. 6*d*. net.

EVERY teacher of biology will no doubt agree that we have for a long time needed a single volume which gives, in the English language, a detailed account of the trematodes written from the point of view of the biologist. The medical man and the veterinarian, confronted with the serious diseases which some species of trematodes cause, have at their disposal excellent accounts of these pathogenic species which necessarily lay emphasis upon the economic, therapeutical or epidemiological aspects of the problems which they raise. In these modern text-books of parasitology two developments are clearly revealed. One is that enormous advances have been made during recent years in our knowledge, not only of the trematodes, but of other helminths also. The second is that the men who gained this new knowledge quickly learned that parasitic organisms cannot be controlled unless they are first understood, and that they cannot be understood unless they are studied precisely as the biologist studies them, namely, as organisms inseparable from their environments and following a certain mode of life in relation to other living things. The parasitologist, therefore, who wishes to control or minimize the damage inflicted upon man and his civilization by parasitic organisms must be primarily a biologist; and nothing shows this more clearly than the fact that most of the advances which we have made in the control of parasitic organisms have been due to increases in our knowledge of their biology. Every modern text-book of parasitology recognizes this and devotes considerable space to the biological background upon which specialized information depends.

Dr. Dawes does not attempt to compete with these more specialized text-books of parasitology. His aim is rather to place at the disposal of everybody a much more detailed account of the biology of the trematodes than any text-book of parasitology could give. It is likely that the medical man and the veterinarian, well qualified by their experience to realize the extent of the service which he has done for them, will be among the first to echo his hope that British biologists will give more attention to the trematodes. Certainly, biologists will find in this book plenty of problems which require further study; for, as the author himself says, they are indicated on almost every page and they are varied enough to occupy a variety of interests, whether these be physiological, biochemical, morphological or taxonomic. For those who like especially intricate problems requiring a knowledge of more than one branch of biology there are the problems of host-relationships and the immunological problems associated with them.

The book begins with a chapter on the Platyhelminthes which places the trematodes in their zoological setting; it contains also a section on the derivation of the names of trematodes, which introduces the student to the mysteries of zoological nomenclature. The structure of the Monogenea and the Digenea is then described, and the next section, which occupies about half the book, is devoted to the classification of both these orders and to the characteristic features of their suborders and families. An immense amount of information is compressed into this section. Keys to the families are given, and there is a useful table of the general characters of the main families of the Digenea. A classification of the various kinds of cercariæ follows, and this is succeeded by chapters on the reproduction, geographical distribution and phylogeny of the trematodes and on their life-histories and the biology of their larval and adult phases. There is an interesting short historical account of work done on the trematodes, and useful notes are given on the collection, preservation, fixation and staining of both the larvæ and the adults. The book ends with a list of nearly 1,600 references to literature. The fact that only about half of these are in English is a measure of the relative amount of work done on trematodes in Britain and in other countries. Many of the papers mentioned are not readily accessible, so that the incorporation of their contents in the pages of this book is a useful service. The index is adequate; but it might be improved in the future editions, for which there will certainly be a demand.

Even a short review of this book cannot be concluded without a reference to the grace and simplicity of the author's style and to the excellence of the publishers' contribution to the making of the book. It may be argued that it is no part of the function of a scientific book to give pleasure to the reader; but the sufficient answer to that argument is the fact that many books written by men of science do give pleasure to their readers and are among the best examples that we have of English literary style and of British book-production. This is such a book, and the reason for it is possibly to be found in the author's statement that, after more than twenty years as a student and a teacher, he has not lost his wonderment at the phenomenon of parasitism. Wonderment? Is that the secret of it all? So long as we can feel that wonderment and can discover and foster it in the young people whom we teach, so long will science progress, and so long will understanding strengthen and humanize the contribution of science to the progress of mankind.

G. Lapage

# A KINETIC THEORY OF LIQUIDS

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THE problem of formulating a rigorous mathematical description of the molecular motion in liquids has always been regarded as much more difficult than that of the kinetic theory of gases or of solids, because one has the simplifying features of low density in the case of gases, and of a regular lattice structure in the case of solids, while the molecules of a liquid are in a dense and disordered state. It is clear that only approximate solutions may be expected; but, in introducing the approximations, we think that the following principle should be accepted. The general equations should be established as rigorously as the present knowledge of the fundamental law permits; the solution of these equations may, however, be obtained by approximations suited to the case.

What is now the situation in the theory of liquids? It is true that a number of attempts have been made to solve special problems with the aid of devices appropriate to each particular purpose; these have been admirably summarized in a recently published text-book by Frenkel[1]. In the special case of equilibrium one has even a rigorous formulation of the general equations, namely, that obtained by applying the methods of statistical mechanics. If, here, the results are meagre, and no comprehensive equation of state is available, this is only because of the formidable mathematical difficulties in reducing and interpreting the formal solutions. It is quite different with the theory of liquids in motion; here no serious attempt to derive the dynamical and thermal equations from the point of view of atomistic theory is known to us*. Enskog[2] in his later work tried to derive a generalization of Boltzmann's equation which would apply to liquids; but owing to a wrong approach, the equation he obtained was still not quite correctly formulated, and contained besides an unknown function which he had no means of determining.

Yet all the fundamental conceptions and laws required for the purpose are known; in the domain of higher temperatures, we have Newton's laws of motion and the principles of statistics and probability, and for lower temperatures, their quantum analogues. The reason why this problem has never been properly tackled seems to lie in the fact that hitherto the engineers have been satisfied with ordinary hydro- and thermo-dynamics, and have had no need of an atomistic sub-structure, while the physicists, interested in atoms and the elementary particles (protons, neutrons, electrons, etc.), have preferred to study gases, where the atoms are almost isolated, or solids, where they act in harmony. However, the situation has changed during the last few years. On one hand, regularities in the values of the molar constants, like the coefficients of viscosity, diffusion and thermal diffusion, have been found, which need atomistic explanation. On the other hand, in low-temperature physics, atomistic and molar behaviour can no longer be separated. In particular, the phenomenon of superfluidity in liquid helium II defies classical hydrodynamics; it is a quantum effect of matter in bulk. All attempts to explain the apparent disappearance of viscosity below the λ-point of helium seem to be futile so long as the mechanism of viscosity in liquids is not known even for ordinary temperatures.

These were the motives which led us to formulate a general kinetic theory of dense matter. It will be published in complete mathematical detail in the *Proceedings of the Royal Society*; but as a period of time will elapse before the later papers of the series will appear, we shall give here a short account of our methods and results.

Comparing the kinetic theory of gases (which applies to dilute systems in equilibrium and in motion) with general statistical mechanics (which holds for any system in equilibrium only), one sees that in the first case a distribution function $f_1(t, x^{(1)}, \xi^{(1)})$ is used which depends on the time $t$, and the position vector $x^{(1)}$ and the velocity vector $\xi^{(1)}$ of a single molecule, while in the second case one has a distribution function $f_N(x^{(1)}, x^{(2)}, \ldots, x^{(N)}, \xi^{(1)}, \xi^{(2)}, \ldots \xi^{(N)})$ which depends not on time, but on the position and velocity vectors of all $N$ particles of the system. These are obviously two extreme cases of a set of functions

$$f_1(t, x^{(1)}, \xi^{(1)}), f_2(t, x^{(1)}, x^{(2)}, \xi^{(1)}, \xi^{(2)},) \ldots, f_N(t, x^{(1)}, x^{(2)}, \ldots, x^{(N)}, \xi^{(1)}, \xi^{(2)}, \ldots, \xi^{(N)}) \quad (1)$$

where each function depends on the co-ordinates and velocities of a number of particles, indicated by the superscripts (1), (2), (3), ..., and time. Our first step consists of introducing this whole set of functions (1), which we call 'multiple distribution functions'.

The function $f_h(t, x^{(1)}, \ldots, x^{(h)}, \xi^{(1)}, \ldots, \xi^{(h)})$, multiplied by the product of the elements of space and velocity around each of the points, measures the probability of finding each of the volume elements occupied by molecules with velocities in the given velocity range. Now, the main feature of a dense assembly of particles is that the distribution function of order $h$ is *not* a product of those of lower order; for example, $f_2(t, x^{(1)}, x^{(2)}, \xi^{(1)}, \xi^{(2)})$ is not equal to $f_1(t, x^{(1)}, \xi^{(1)}) f_1(t, x^{(2)}, \xi^{(2)})$. There are, however, obvious relations between consecutive functions; for example, by integrating $f_{h+1}$ over the range of co-ordinates and velocities of the last particle, one obtains $f_h$, apart from a normalizing factor $(N - h)$.

We need also to generalize the conception of distribution function by taking as arguments for each molecule, not only the position and velocity vectors, but also the acceleration vectors $\eta^{(i)}$; these functions we write $g_h(t, x^{(1)}, \ldots, x^{(h)}, \xi^{(1)}, \ldots, \xi^{(h)}, \eta^{(1)}, \ldots, \eta^{(h)})$. If $g_h$ is integrated over the ranges of the $\eta^{(i)}$, one obtains $f_h$, and if $f_h$ is integrated over the $\xi^{(i)}$, one obtains the number density functions $n_h$, which depend only on the position vectors $x^{(1)}, \ldots, x^{(h)}$, and time. The condition that a group of $h$ molecules preserves its identity in the course of the motion is a kind of multi-dimensional continuity equation for each of the functions $n_h, f_h, g_h$. The most important of these is the equation for $f_h$, which has the form

$$\frac{\partial f_h}{\partial t} + \sum_{i=1}^{h} \frac{\partial f_h}{\partial x^{(i)}} \cdot \xi^{(i)} + \sum_{i=1}^{h} \frac{\partial}{\partial \xi^{(i)}} \cdot (f_h \overline{\eta^{(i)}}) = 0. \quad (2)$$

Here $\overline{\eta^{(i)}}$ is the mean acceleration of the molecule $(i)$ obtained by averaging $\eta^{(i)}$ with the help of the distribution function $g_h$.

Now the main point of the theory is reached: this mean acceleration can be expressed in an alternative way, with the help of Newton's equations of motion.

* (*Note added in proof.*) We are indebted to Prof. E. N. da C. Andrade for directing our attention to an important paper recently published by J. G. Kirkwood (*J. Chem. Phys.*, **14**, 180: 1946), in which he approaches our problem from the point of view of statistical mechanics and the Brownian movement, and succeeds in deriving our equation (2). In the work so far published, he does not, however, appear to have developed this equation to any great extent.

These give the acceleration of one molecule in terms of the forces due to all the others. The resultant force may be regarded as due to two actions: first, that of the remaining $h-1$ particles of the group, and secondly, that of all the rest. As the configuration of the $h$ particles is known, the averaging of the force must be performed only over the other; this is effected by integrating over all configurations of a single particle in an arbitrary position, supplied with the weight $f_{h+1}/f_h$. Hence $\overline{\eta^{(1)}}$ can be expressed in terms of an integral containing $f_{h+1}$ in the integrand, and when this is substituted into (2) one obtains an integro-differential equation connecting two consecutive functions $f_h$ and $f_{h+1}$.

The result is a chain of $N$ integro-differential equations for the set of functions $f_1, f_2, \ldots, f_N$, which formulate the statistical laws of motion in a rigorous way. Each equation has the form (2), and contains one 'statistical term' involving, through $\overline{\eta^{(1)}}$, the following function $f_{h+1}$. The first task of a new theory is to show that it contains well-established special cases. We therefore require to prove that the Maxwell–Boltzmann kinetic theory of gases is a limiting case. This is effected by assuming the density to be so low that only binary encounters between the molecules need be taken into account, so that the function $f_2$ is, for large distances between the particles ($|x^{(2)}-x^{(1)}|$ large), a product $f_1(t, x^{(1)}, \xi^{(1)})\, f_1(t, x^{(2)}, \xi^{(2)})$. Then the statistical term in (2) can, for $h=1$, be transformed exactly into the 'collision integral' well known from the kinetic theory of gases, and the equation becomes identical with Boltzmann's integro-differential equation, from which all the thermo-mechanical properties of gases can be derived (*cf.* Chapman and Cowling[2]).

The second limiting case is that of equilibrium, where the new theory ought to be identical with statistical mechanics. It is easy to show that, if Gibbs's canonical distribution function is taken for $f_N$, and $f_{N-1}, f_{N-2}, \ldots, f_2, f_1$ are derived from it by integration, all our equations are satisfied. The proof rests essentially on the fact that no function $f_{N+1}$ exists; hence the equation (2) has no statistical term for $h=N$. One can prove much more, however, namely, that under reasonable conditions, any configuration approaches the equilibrium distribution, so that the statistical motion is an irreversible process. The proof is very similar to the corresponding one in the kinetic theory of gases; it uses the notion of the $H$-function (negative entropy) defined in a way suggested by ordinary statistical mechanics. The validity of the $H$-theorem depends on a proper choice of the conditions under which the system is considered. If one assumes the system to be closed and completely independent of the outer world, no irreversibility can be expected. The last equation would then contain no statistical term, and as all of $f_{N-1}, f_{N-2}, \ldots, f_2, f_1$ can be expressed in terms of $f_N$, the solution would have no statistical character. One has to assume that the system of $N$ particles is in thermal contact with a bigger one, which can be assumed to consist of the same kind of particles; this introduces in the $N$th equation a statistical term containing $f_{N+1}$. Then the original system of $N$ particles satisfies the $H$-theorem. In this way the new theory proves to be completely self-contained; it does not rely on results known from statistical mechanics, but contains this theory as a special case.

Although one would scarcely expect new results in this special case of equilibrium, we have investigated it again with our new methods, and find that these lead to new approaches to the intractable integrals of statistical mechanics. Our main general result is that all thermodynamical properties of the system can be expressed in terms of the function $n_2$ alone, which expresses the probability of finding two particles at given positions $x^{(1)}$, $x^{(2)}$. In the equilibrium of fluids, it depends obviously only on their distance $r$, and is identical with the radial distribution function determined in experimental investigations on the scattering of X-rays by monatomic liquids. Moreover, all thermodynamical quantities can be expressed in terms of the Fourier transform of $n_2(r)$, which is directly given by the intensity distribution of the scattered X-rays. Hence the thermodynamics of a liquid are reduced to the knowledge of this experimental function. The rigorous theoretical treatment leads to the well-known formidable difficulties in evaluating the partition function of statistical mechanics; the new formulation, however, suggests a different approach, which, though only approximate, can be easily improved. As we have pointed out, the second distribution function, depending on two particles, is not a product of two functions, each depending on one of the two particles. For example, $n_2(x^{(1)}, x^{(2)})$ differs from the product of $n_1(x^{(1)})$ and $n_1(x^{(2)})$ (which in equilibrium are both constant and equal). In the same way, the equation

$$n_1^3\, n_3\,(x_1, x_2, x_3) = n_2\,(x^{(2)}, x^{(3)}) \\ n_2\,(x^{(3)}, x^{(1)})\, n_2\,(x^{(1)}, x^{(2)}) \qquad (3)$$

will not hold exactly, but will be a much better approximation to the real situation than $n_2(x^{(1)}, x^{(2)}) = \text{const}$. If this equation (3) is not sufficiently accurate, one can use it as a first approximation and then assume a similar expansion for $n_4$ in terms of $n_3$, and so on.

In fact, Kirkwood[4] has shown that (3) leads to reasonable results; so we have accepted it and called it the 'Kirkwood' approximation. With its help, $f_3$ can be eliminated from the statistical term in the second equation (2), which together with the first then forms a closed system for the determination of $f_1$ and $f_2$. They can easily be reduced to a single integral equation for $n_2(r)$; it is a generalization for arbitrary central forces of an equation already established and solved by Kirkwood for 'rigid spherical molecules'.

We have succeeded in solving our equation for the general case, and find that at low temperatures there exist solutions which indicate an almost periodic behaviour of $n_2$; we believe that these correspond to the solid state (lattice structure). A Russian physicist, Vlasov[5], has published some papers in which he tries to derive the existence of crystal lattices from a Maxwell–Boltzmann equation in which the mutual forces of the particles are introduced, but the statistical term completely neglected. Although it seems to us that this attempt was not entirely successful, we believe that Vlasov's idea will prove correct.

Other solutions of the integral equation for $n_2(r)$ which for large $r$ tend to the constant $n_1^2$ correspond to the liquid state. They have the well-known features of the radial distribution function in liquids: a set of density maxima the amplitudes of which rapidly decrease with $r$.

The $n_2(r)$ thus found can be used to obtain expressions for the free energy, from which all thermodynamical quantities can be derived. For low densities (gas), the pressure can be expanded in a series of powers of the density

$$p = \sum_{k=1}^{\infty} \beta_k n_1^k, \qquad (4)$$

where the coefficients, the so-called virial coefficients, are functions of the temperature. Mayer[8] has succeeded, by a rigorous combinatory method, in finding expressions for the $\beta_k$ in terms of integrals involving the potential energy $\varphi(r)$; but only the first few of these 'cluster integrals' could be evaluated, even for simple force laws. Our method produces for the $\beta_k$ simple definite integrals which are much more tractable. Mayer has shown that the power series (4) ceases to converge at a definite density for each temperature, which he has associated with the point of condensation. But neither his work nor that of others (Born and Fuchs[9], Kahn[8], etc.) has succeeded in elucidating the character of the singularity or penetrating beyond it into the liquid region. Kahn has given an expression for the analytic continuation of the power series (4) into the region beyond the circle of convergence, but has misinterpreted his results. He accepts the well-known $p$–$v$ diagram in which an isotherm is usually drawn with a horizontal part ($p$ = const.) connecting the branches which represent the vapour and the liquid, and he endeavours to show that Mayer's method leads rigorously to such a region $p$ = const., representing the process of condensation. In fact, this graphical representation of condensation by a line has no significance; the correct formulation is, that for a certain domain of pressure and temperature, the equation of state has two solutions $v_1$, $v_2$, for the specific volume, corresponding to stable states in equilibrium, vapour and liquid. The expression for $p$ found by Kahn which he considers to be constant is, in fact, a function of volume; his error is due to his assumption that all the virial coefficients $\beta_k$ are constant, whereas they depend on the volume more and more as $k$ approaches the number of molecules in the liquid. Kahn's expression for $p$ is the equation of state for the liquid, though in a quite untractable form.

Our theory shows that the liquid differs from the gas by the existence of real roots of a certain transcendental equation, revealing at once the analytical character of Mayer's singularity as a branch point, and allowing the derivation of an explicit equation of state in terms of the complex root of the same transcendental equation. The formulæ obtained are quite manageable; a numerical discussion is in progress.

The main object of our investigation is, of course, the derivation of the thermo-mechanical equations of motion and a determination of the coefficients of viscosity, thermal conductivity, etc., in terms of the atomic interaction. A new feature of this theory is that one obtains not only the ordinary equations of hydrodynamics (including the equation of the flow of heat), but also generalized ones describing simultaneously the motion of groups of molecules. In these there appear the mean number densities $n_1$, $n_2$, ..., $n_k$, the corresponding mean velocity vectors, $u_1^{(i)}$ $u_2^{(i)}$, ..., $u_k^{(i)}$, and the mean kinetic energies or 'temperatures' $T_1^{(i)}$, $T_2^{(i)}$, ..., $T_k^{(i)}$. The latter concept is of particular interest. These molar equations are solvability conditions of a kind for the integro-differential equations for the distribution functions $f_k$. The equations for $f_k$ have a great many solutions which have no significance for our purpose (describing, for example, such configurations, where one particle is shot through the rest with an exceedingly high velocity, as may happen in radioactive processes). We have, therefore, singled out for study those 'normal' solutions, corresponding to ordinary hydrodynamics, where the state of the system is completely determined by the values of $n_1$, $u_1$ and $T_1$ for one particle, throughout the fluid. It appeared that the classical method developed by Hilbert[8], Enskog[10], and Chapman[11] in the kinetic theory of gases (virtually equivalent to an expansion in inverse powers of the mean free path) was useless for liquids, because there the free path becomes vanishingly short, and the mutual exchange of potential energy between the molecules correspondingly large. We therefore developed a new method of expansion in powers of the space gradients of the density, mean velocity, and temperature.

The result is, that all properties of a liquid in motion are, just as in the case of equilibrium, compounded of two parts, due to the thermal motion and the intermolecular forces respectively. The first, which is the only one considered in the theory of gases, is quite insignificant in liquids; when it is neglected, one obtains the coefficients of viscosity and thermal conduction as integrals involving the radial distribution function and its distortion by the motion.

The actual determination of this distortion is rather complicated, but one can obtain practical results without actually solving the appropriate integral equation. For it is evident that $n_2$ will have the form $n_2^0(1+\alpha)$, where $n_2^0$ is the equilibrium function, and $\alpha$ a correction due to the motion; the dependence of $\alpha$ on temperature and density can be determined by a simple dimensional consideration. The resulting integral can be evaluated by the method of steepest descent, as soon as the potential energy $\varphi(r)$ between two molecules is known. To give a concrete example, let us choose a function of the kind proposed by Lennard-Jones[12], $\varphi(r) = -ar^{-6} + b/r^{12}$, the first term corresponding to the van der Waals attraction in the form obtained by London[13]. Then one obtains for the coefficient of viscosity

$$\mu = c \left(\frac{r_0}{r_1}\right)^5 \frac{m\nu_0}{r_0} \exp - \varphi(r_1)/kT. \qquad (5)$$

Here $c$ is a numerical constant, $r_0$ the equilibrium distance of two particles (diatomic molecule), given by $\varphi'(r_0) = 0$, $r_1$ the actual mean distance of neighbouring particles, and $\nu_0 = \{\varphi''(r_0)/4\pi^2 m\}^{\frac{1}{2}}$ the frequency for the diatomic molecule.

One may compare (5) with the empirical formulæ of the type mentioned by de Guzman[14], and first established and studied in detail by Andrade[15]. At the melting point, Andrade's formula reads $\mu \sim \frac{m\nu_1}{r_1}$, where $\nu_1$ is the frequency determining the specific heat, which may be taken, for example, from *Reststrahlen* results or put in terms of Lindemann's formula. One recognizes this factor in our formula (5), but with constant $r_0$ and $\nu_0$ referring to the diatomic molecule. However, our formula depends on the volume in a different way from Andrade's, namely, by the factor

$$\left(\frac{r_0}{r_1}\right)^5 = \left(\frac{v_0}{v_1}\right)^{5/3}.$$

In fact, Andrade's ingenious derivation is based on a simplified physical picture which by its nature must fail to give dimensionless factors $\left(\text{powers of } \frac{v_0}{v_1}\right)$. Also Andrade finds the exponential factor, but gives no theoretical explanation except that it must be a kind of activation and, therefore, have the form of a Boltzmann factor.

A different formula for the coefficient of viscosity has been given by Fürth[16]. It is based on his theory of 'holes'; the liquid is regarded as a continuum of small bubbles, the size and apparent mass of which depend on the surface tension. These bubbles perform a kind of Brownian movement, and transfer energy and momentum; the coefficient of viscosity can thereby be expressed in terms of the surface tension. Fürth's formula contains an exponential factor of the same type as ours; the remaining factor cannot be compared with ours because of the entirely different assumptions made. But Fürth has shown that his formula is practically identical with Andrade's because of some empirical relations between the constants involved; and similar considerations can be applied by comparing Fürth's formula, or that of Ewell and Eyring[17], with our own.

Our theory also provides an account of the variation of the apparent viscosity of liquids under the action of external forces, such as electric and magnetic fields. One general conclusion here is that the field cannot by itself produce any change in the apparent viscosity if it can be derived from a scalar potential; this appears to be in accord with the recently published experimental work of Andrade and Dodd[18]. On the subject of conducting liquids and the effect of alternating fields, which they have also studied, we have not yet reached any definite conclusion; this remains a subject for further study.

We hope to generalize the theory also in the following different directions. The first and most obvious step is the introduction of internal degrees of freedom of the molecules; this is probably closely connected with giving up the assumption of central forces. Then mixtures of two or more kinds of molecules have to be considered in order to obtain the laws of ordinary and thermal diffusion; the latter (Soret effect) will be of special interest, as no theory for liquids seems to exist (see the dissertation by de Groot[19], Chap. 5). Also our theory gives, as we have mentioned before, clear indications of the appearance of the solid state; we hope that it will lead to a better understanding of the present lattice dynamics and its limits, in particular to theories of melting and plasticity.

The most important generalization envisaged is the introduction of quantum mechanics. For there are known several examples of quantum 'liquids': helium II (superfluidity), the substance of nuclei (droplet model), and perhaps also electrons in metals (superconductivity). It is, of course, hopeless to try to understand the abnormal viscosity in liquid helium if one has no theory of viscosity in normal liquids; this gap has now been closed, and we plan to extend our theory of viscosity to quantum liquids.


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# ORIGIN OF ERYTHROCYTES


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CONVENTIONAL views on hæmopoiesis may be said to be well founded, in spite of the fact that beliefs in the transformation of precursor elements to definitive blood cells, through a series of specific cell stages, represent, so far as the adult mammal is concerned, dynamic concepts based upon more or less discontinuous observations—in the sense that no one has observed, either *in vitro* or otherwise, the whole process of transformation in adult tissue. Because of this it is not surprising that the facts have been interpreted differently at different times, and that more than one view has been advanced about the development of the blood elements. Equally, it is not surprising that commonly expressed views fail to account for all the known facts. The observations that are reported in this note fall so far outside current generalizations that they seem to lend themselves to a complementary hypothesis of blood formation.

If striated mammalian muscle that has been subjected to trauma is immediately fixed, cytological examination sometimes reveals the presence of very numerous cell elements that appear to constitute a continuous series of transition forms between muscle cells and granulocytes (in the rat, eosinophils in particular). As this observation could be taken to imply that muscle cells were being immediately transformed into leucocytes, as has been described by v. Möllendorff[1] and his school[2] in the case of fibroblasts, a series of experiments was undertaken in which muscle was first excised and the injury inflicted *ex situ*, in a place chosen arbitrarily. These appear to show that extensive leucocytosis, accompanied by great numbers of transition forms, may occur in a muscle after its removal from the body. The circumstances obviously exclude the possibility of migration of leucocytes from the blood vessels, and also appear to preclude their origin from connective tissue cells, since cytological study of what seem the earliest transition forms suggests much more their derivation from muscle cells. The breakdown of the cellular muscular network results in the appearance of free cellular elements; and nuclear secretion appears to be the main factor responsible for the production of leucocyte granules. The process is so rapid that it has more the character of a cell-catastrophe than that of a slow transformation. The possibility of such a change is implied in Maximow's[3] final paper, where it is stated that, in areolar tissue, the transition forms ('Lochkerne') appear only very rarely in specimens in which the possibility of injury during preparation has been minimized so far as possible. This observation obviously implies that rougher treatment stimulates their instantaneous appearance.

Intense secretory activity is not confined to the muscle nuclei of injured muscle. It is a constant finding in a working and anoxic muscle, although in this case it leads not to the production of granules, but to significant changes in the muscle-columns adjacent to the active nuclei. Thus whereas in the resting muscle the sarcomeres are neatly levelled, in activated muscle-columns the nonius-periods appear, and this in places results in a complete release of sarcomeres. This process is always accompanied by

Fig. 1. WORKING MUSCLE (RAT). RELEASE OF SARCOMERES: THOSE LOWER DOWN HAVE THE APPEARANCE OF ERYTHROCYTES

Fig. 2. ISCHÆMIA OF SHORT DURATION (RABBIT). APPARENT ABORTIVE ERYTHROPOIESIS RESULTING FROM THE TRANSFORMATION OF TWO MUSCLE-COLUMNS

Fig. 3. MUSCLE DEGENERATION AFTER 5 DAYS (INJURY: FREEZING). APPARENT TRANSFORMATION OF THE WHOLE MUSCLE FIBRE

Fig. 4. WORKING MUSCLE (FROG). ABOVE: APPARENT ORIGIN OF FIVE THROMBOCYTES. BELOW: BUDDING OFF OF AN ERYTHROCYTE NUCLEUS

a striking change in the staining reaction of the sarcomere (best followed in Mallory stained sections), and by a marked increase of their refraction index (Fig. 1). The *A* disks of these sarcomeres, even before release, have a brilliant orange (eosin) or red (Mallory) coloration, contrasting with the pale colour of the alternating *I* disks. These observations can be related to the early findings of Bowman[4] (Bowman's disks) and to those of Thoma[5], who found that in certain conditions "the discoidal disintegration begins suddenly in an almost explosive manner". Reconstruction-models reproduced by Aurell and Wohlfart[6] provide useful information about the disposition of sarcomeres in the striated muscle, and the varying appearances which can be observed (nonius-periods, helicoidal fibres, staircase effect, sphenodes) would seem to constitute different stages in a process of sarcomere release.

The release and transformation of sarcomeres appear to be even more conspicuous in those forms of degeneration of striated muscle which are accompanied by hæmorrhage. The injury causing degeneration brings about a breakdown of the cellular network and a marked slowing down of the secretory process, while the nuclear secretion spreads more diffusely, and is not confined to discrete muscle-columns. As a result, a massive but abortive and stationary transformation appears to occur. In such cases (Figs. 2 and 3) the more or less freed sarcomeres are indistinguishable from erythrocytes. At the same time, isolated and secreting muscle cells appear to undergo an immediate transformation into lymphocytes. Rous[7] has shown that the number of lymphocytes delivered through the thoracic duct is increased fourfold as a prompt result of muscular activity. He concluded that "the variations caused by muscular exertion . . . are so pronounced as to suggest that the total number of lymphocytes in circulation must be considerably influenced by them. Clinical findings of other observers indicate that this is true. . . !"

All these cytological observations seem to call for a different, or at least an additional, approach to the problem of mammalian hæmopoiesis. Although it is recognized that in the early embryo red blood cells differentiate from primitive mesenchyme, their formation in later stages and in the mammal after birth is assumed to follow a series of fixed stages in their derivation from a nucleated cell in the red marrow. The basis of this genealogy is admittedly incomplete, and in part derives from a study of frank pathological conditions. One of its major difficulties is to explain the fate of the nucleus of the normoblast, in spite of the fact that its lysis (or extrusion) should be an extremely common occurrence.

Nevertheless, without prejudice to this conventional hypothesis, on which they do not touch directly, the observations that are summarized in this note suggest that there may be another source of red cells in the body—striated muscle. They seem to indicate, first, that mammalian red blood elements may be 'cell products (plastids) non-homologous with cells', as was suggested more than fifty years ago on completely different grounds by Minot[8], and second, that striated muscle, owing to its high and immediate

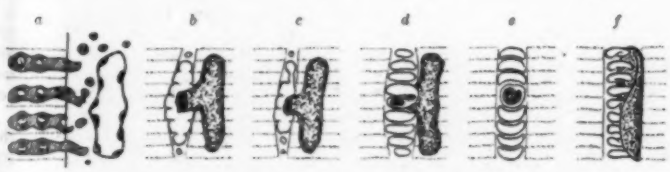



Fig. 5. COMPARATIVE ANATOMY OF ERYTHROPOIESIS (TENTATIVE SCHEME)

*a* Insects (redrawn from Holmgren[14]): trophospongial connexions between the muscle nucleus and sarcosomes.
*b* Frog: erythropoiesis (from observation *in vivo*); *cf.* Fig. 4.
*c* Frog: thrombocytopoiesis (from observation *in vivo*).
*d* Batrachoseps, tentative drawing based on figures given by Emmel[13].
*e* Mammal: lymphocytic hæmal unit homologous to the amphibian erythrocyte (from photomicrographs).
*f* Mammal: endothelial hæmal unit *f*

requirements of oxygen, is a store of partly preformed 'erythroplasts', and that it constitutes an erythropoietic organ of the normal mammal. As the muscle cells involved in the process assume, as a rule, the role of capillary endothelium, on our hypothesis erythropoiesis in these conditions is always intravascular: the 'opening up' of the muscular capillaries proceeds *pari passu* with the production of erythroplasts in their lumina—that is to say, muscle-columns may become transformed into blood-cell-bearing capillaries. By way of contrast, the question whether erythropoiesis is extravascular or intravascular remains controversial in the framework of current theories.

The likelihood that leucocytes and histiocytes can also be derived from muscle cells can be related to the analogous transformations of fibroblasts, as described by v. Möllendorff *et al.*[1,2]. On the hypothesis advanced here, striated muscle differs from mesenchyme by its immediate erythropoietic capacity. In this connexion it should be noted that Chèvremont[9] has recently conclusively shown that embryonic muscle cells in tissue culture may become transformed into histiocytes.

On the basis of our own evidence, as well as on that of other workers, the production of leucocytes may be regarded as a by-product of erythropoietic and vasoformative activity. In the frame of the working hypothesis put forward here, leucocytes can be regarded as the cellular waste, in the strictly morphological sense, of these processes, resulting from a partial or abortive response to the erythropoietic stimulus (probably anoxia) of some muscular elements.

The steps in this cytologically based hypothesis are set out in Tables 1 and 2.

Table 2 includes a reference to the 'vasoformative cells' of Schafer[10] and Ranvier[11], who remarked on the intracellular formation of red plastids as early as 1873 and 1874 respectively. It is also suggested that a single mesenchyme cell, be it a fibroblast or a myoblast, responds to anoxia in one particular way only, and that the end-forms into which they are transformed do not change one into another. Further, it follows that the process of inflammation may be regarded as the erythropoietic and vasoformative effort, more or less successful, of anoxic tissue.

A further study of surviving, as well as fixed and stained, frog muscle has shown that the nuclei of erythrocytes bud off from the muscle nuclei (Fig. 4), and suggest that the erythrocyte nuclei incorporate a number (6–8 ?) of sarcomeres into their cell body. This seems to explain the findings of Emmel[13] and others on the non-nucleated 'erythroplastids' of *Batrachoseps attenuatus* Esch., as well as the presence of bundles of myofibrils in amphibian erythrocytes, as has been recorded by Meves[15] and also by other workers.

Fig. 5 presents a scheme of a tentative comparison of erythropoiesis in vertebrates, and includes the phenomena described in the muscle of insects by Holmgren[14].

I wish to thank Prof. S. Zuckerman for advice and criticism in the presentation of this new working hypothesis.

TABLE 2. HÆMOPOIESIS IN MUSCLE. INFLAMMATION. THE BREAKDOWN OF CELLULAR NETWORK. ERYTHROPOIESIS PARTLY EXTRAVASCULAR ('DIAPEDESIS') AND INADEQUATE, OFTEN MASSIVE BUT ABORTIVE (STASIS, THROMBOSIS). TISSUE ANOXIA ELICITS PARTIAL RESPONSE OF THE VESSEL-BUILDING CELLS (GRANULOPOIESIS, LATER HISTIOPOIESIS). CELLULAR WASTE INCREASED AND NOT REMOVED (SUPPURATION, NECROSIS)

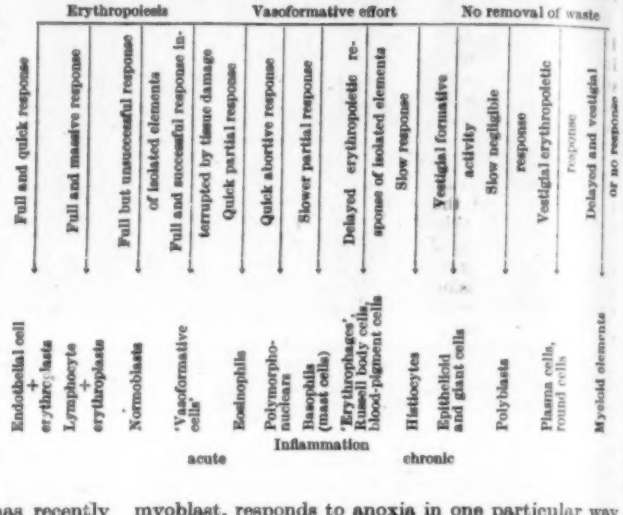
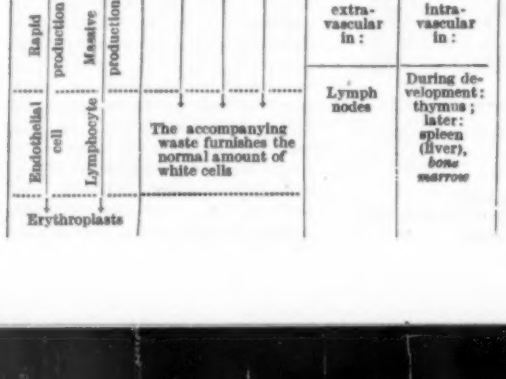



TABLE 1. HÆMOPOIESIS IN MUSCLE. POSSIBLE NORMAL COURSE OF EVENTS. CELLULAR NETWORK REMAINS CONTINUOUS. ERYTHROPOIESIS STRICTLY INTRAVASCULAR AND ADEQUATE. NO TISSUE ANOXIA DURING VASOFORMATIVE ACTIVITY. SCANTY CELLULAR WASTE IS QUICKLY REMOVED

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# BRITISH COMMONWEALTH SCIENTIFIC CO-OPERATION

THE Report of Proceedings of the British Commonwealth Scientific Official Conference, London, 1946*, in addition to the Recommendations and Resolutions of the Conference, includes the opening statements of the Lord President of the Council and of the chairman of the Conference, Sir Edward Appleton, as well as a brief historical review showing the sequence of the Conference to that held in 1936, and its relation to the Royal Society Empire Scientific Conference which immediately preceded the Official Conference, and the recommendations from which are appended to this report. The Official Conference, which met during July 9–19, had as its terms of reference "to consider the best means of ensuring the fullest possible collaboration between civil Government scientific organisations of the Commonwealth and to make formal recommendations for the approval of the Governments represented". Defence science was not considered, and the working of the Imperial Agricultural Bureaux was reviewed at a further conference during the following week. Arrangements for the Conference were entrusted in October 1945 to a Working Party of the Civil Science Panel under the chairmanship of Mr. O. F. Brown, while on the arrival of the delegates in London, the heads of oversea delegations, together with the secretaries of the Department of Scientific and Industrial Research, the Agricultural Research Council and the Medical Research Council and a representative of the Colonial Office, formed a steering committee with Sir Edward Appleton as chairman and Mr. O. F. Brown as secretary.

In his opening statement, Mr. Herbert Morrison, emphasizing that it was possible to pay too much attention to organisation, pointed out that throughout the British Commonwealth we shall be faced for some years to come with an acute shortage of scientific man-power. Accordingly, there is a risk that too elaborate organisation might result in absorbing into the administrative machine many trained scientific workers who are badly needed in research laboratories, in universities or similar institutions, in Government laboratories or in industry. Sir Edward Appleton, also referring to the importance of a proper balance between university research and research under Government auspices, said that in Great Britain we have tried to avoid the danger of static Government research institutions by budding off new establishments from existing ones as need arose. He recognized the importance of active attention to the maintenance of the scientific health and outlook of workers in the Civil Service. University conditions generally ensure the maintenance of the mental adventurousness and lively imagination so necessary for scientific progress, and Sir Edward Appleton stated that an Interdepartmental Scientific Panel, of which he is chairman, is now considering the implementation of the recommendations of the Barlow Report on scientific staff. He urged that official scientific workers should do all that they can, when necessary, to convince their Governments of the importance of the Royal Society's Scientific Conference proposals for extending facilities for independent fundamental research at universities throughout the Commonwealth, and he pointed out that the pension provision of the civil 'scientific officer' grades in the United Kingdom scientific service is in most Departments specially designed to facilitate the movement of workers. The Department of Scientific and Industrial Research in particular favours such transfers as encouraging both fundamental research at the universities and applied research in industry.

One session of the Conference was in fact devoted to the movement of scientific men. The subject was discussed under four heads: the general need for interchange; student interchange within the Commonwealth; interchange of scientific staffs within the Commonwealth; and movement of scientific workers to assist territories outside the Commonwealth. Resolutions were passed urging steps to promote the maximum general interchange and supporting the Royal Society's Conference recommendation for the central compilation, classification and publication of lists of post-graduate scholarships available for scientific study within the Commonwealth, a task which would be appropriate to the proposed British Commonwealth Scientific Office, and favouring the provision of further travelling fellowships for post-graduate work, in particular the establishment of research fellowships tenable by United Kingdom students in the Dominions and in India. Other recommendations urge the exploration by university authorities of the possibility of co-operation in the award of post-graduate degrees; the exemption from income tax of all travelling scholarships and travel grants, and adoption of a system of adequate financial provision for travelling and subsistence allowances to avoid undue financial burden on the individual in travelling abroad for the purposes of study; special concessions for scientific workers travelling abroad for study, for attendance at scientific conferences and for similar purposes. The recommendations of the Royal Society's Conference that staff complements should be raised to a level sufficient to offer individuals adequate time for research, for study, and for travel leave without, thereby, placing additional burdens on their colleagues, are supported. Standard conditions are suggested for the temporary transfer of scientific workers, and the report of a committee set up by the Conference to consider superannuation was adopted. This report recommends the adoption throughout the Conference of a scheme or schemes with superannuation benefits not less favourable than those of the Federated Superannuation System for Universities. This session also noted the increasing demands from territories outside the Commonwealth for expert scientific advice, and suggested that such requests should pass through a British Commonwealth Scientific Office, London, so that the resources of scientific man-power and of educational establishments in other parts of the Commonwealth as well as of the United Kingdom may be used to the best advantage.

The first session of the Conference was concerned with the question of scientific liaison offices in view of its bearing on many of the other problems before the Conference. Sir Edward Appleton referred to the success of the appointment of scientific liaison officers during the War, and the first resolution of the Conference endorsed the views expressed in a resolution from the Royal Society's Conference on the functions of liaison offices as an essential part of the machinery for facilitating interchange of scientific workers and related activities. The Conference warmly welcomed the proposals for setting up a

* British Commonwealth Scientific Official Conference, London, 1946. Report of Proceedings. Pp. 73. (London: H.M. Stationery Office, 1946.) 1s. 3d. net.

liaison office in London in which the several scientific liaison offices of the various parts of the Commonwealth would be housed under one roof, and certain common services such as library and records, typewriting, photographic services, microfilming, and photostating would be pooled, and invited the Governments concerned to proceed with the necessary arrangements as soon as possible. The Conference also regarded the British Commonwealth Scientific Office in Washington as a valuable and necessary element in the permanent machinery for scientific liaison, but recommended a change of name to "British Commonwealth Scientific Office, North America". A committee set up by the Conference, under Dr. E. Marsden as chairman, formulated detailed proposals regarding accommodation and common services, administration and finance for the London and Washington Offices to be subject to review in three years time, which were later adopted by the Conference.

The next session, considering collaborative research and specialist conferences, at which Sir David Rivett presided, adopted a resolution recognizing the need for a standing committee which would be responsible for the arrangements for specialist conferences, in co-operation with appropriate Commonwealth or international bodies. It was recognized that, whereas there are subjects in which the work can be left to develop along its own lines, the workers merely requiring to be aware of what is going on in their fields in other parts of the Commonwealth, to be able to exchange information quickly and to be acquainted with progress in the development of new techniques and results, in other subjects a concerted attack is necessary. At its opening session the Conference had appointed committees on the agricultural sciences, medical sciences, and oceanography and fisheries to consider questions of collaborative research, and to these committees this session now referred a number of recommendations from the Royal Society's Conference.

To the Medical Science's Committee there were thus referred the recommendations on the physiological and psychological factors affecting human life under tropical conditions and in industry; the etiology and control of infectious and transmissible diseases; and on measures for dealing with the special nutritional problems of the British Empire, including the nutritional status of the indigenous peoples of the Colonies. In addition, the Conference referred to this Committee two recommendations: (1) that the attention of Governments of the Commonwealth in countries where malaria is prevalent should be directed to the urgent need of integrating fish-culture practice with measures for malaria control; and (2) that in view of the steady increase in the demand for insulin, all countries of the Commonwealth should make every effort to collect, process and preserve all available pancreas. The report of this Committee, which was adopted by the Conference, recommended that in each Dominion there should be a body sponsored by the Government and responsible for stimulating, supporting and organising medical research, and that each Dominion organisation should establish an effective liaison with the others so as to provide machinery for the discussion on strategy of research on problems of wide mutual interest, for calling specialist conferences when required, and for the movement of scientific workers between different parts of the Commonwealth. In endorsing the recommendations referred to it, this Committee urged the necessity for developing at all levels of Dominion and Colonial government a proper awareness of the nutritional needs of the indigenous peoples and also the need for more food technologists.

The Agricultural Sciences Committee recommended that the standing committee should examine the feasibility of calling at an early date a joint conference of specialists to explore the problems concerned with the integration of the three main branches of agricultural science. Of the subjects of the specific recommendations of the Royal Society's Conference referred to the Committee, soil conservation and land utilization, the maintenance of soil fertility with special reference to the role of soil organic matter, soil deficiencies in relation to plant and animal nutrition, the ecology of plants and animals of agricultural importance, and grassland and pasture research were suggested as suitable for discussion at such a conference. The control of vegetation by chemical means, insecticides and fungicides, pests in stored products, methods of collection and statistical analysis of data relating to agriculture, and biological control of insects and weeds are subjects recommended for inclusion in future specialist conferences.

The Committee was greatly impressed by the need for securing more adequate meteorological data as a basis for climatic studies, and the subject was considered by a sub-committee, which recommended the establishment at representative centres of meteorological stations equipped to measure the factors of moisture, light and temperature affecting biological activity, and indicated specific needs to be met. The equipment of biological field research stations was also recommended. The full Committee also recommended that the attention of Governments be directed to the need for preliminary surveys of the extent of utilization and of wastage of agricultural products in their individual territories as a basis for research, and to the importance of preserving native breeds of farm stock to serve as a source of breeding material, and of defining the structural and functional characteristics of such breeds. Further subjects recommended for reference to other committees or conferences included the provision of improved facilities for collecting living plant materials and for maintaining varietal collections of economic species; the extension of taxonomic and other biological research at museums and botanic gardens; and the utilization of aerial survey methods for studying and estimating crop areas and for detecting locust swarms. Various problems of plant physiology, genetics and pathology, and of the physiology of domesticated animals, suggested by the Royal Society's Conference for further research, were recommended for bringing before the notice of the appropriate government and university authorities.

The Oceanography and Fisheries Committee endorsed the various recommendations of the Royal Society's Conference referred to it and recommended particular attention to long-term research, in which regional co-operation should be an aim. The establishment of wave-recording stations to permit collaborative investigations of sea and swell conditions was also recommended, and the Committee stressed the need for the dissemination of information on oceanography, limnology, fisheries research and technology, especially to isolated research workers. The establishment of a journal for Colonial fisheries and oceanography would be welcomed.

Other committees were set up to consider radio and cosmic ray research; the establishment of a Commonwealth collection of type cultures; mineral resources and geology; building research; fuel research; food preservation; and regional research in Africa. Reports with recommendations from all these committees, which are detailed in the report, were considered at the 'review sessions', and the Conference also endorsed the recommendations of the Royal Society's Conference on modern methods of mapping and exploration by air.

Discussion at the session of the Conference devoted to aspects of collaboration in research between Government and industry centred mainly around the question of research associations. Concerning the publication of results, it was emphasized that practically all results of scientific work are published as papers before societies or printed in scientific periodicals. The Conference adopted a resolution noting with satisfaction the growth of the research association movement within the Commonwealth, and recommending no departure from the present practice whereby Government departments, research institutions or firms in Commonwealth countries, wishing to participate in the benefits of membership in a particular research association in another Commonwealth country, negotiate on a mutually satisfactory basis for membership with the Association concerned.

At the session on information services, the Conference adopted a resolution endorsing the general recommendation of the Royal Society's Conference regarding a conference on abstracting and information services, but recording the view that such a discussion should be regarded as preliminary to a wider conference to which the United States, as well as operating agencies of the United Nations concerned with the subject, should be invited. It was also recommended that the suggested British Commonwealth Scientific Office in London should organise machinery for ensuring that there is within each co-operating country a list of translations of scientific papers, made or contemplated throughout the Commonwealth, in languages other than English. A committee appointed to consider proposals for alteration in the organisation and functions of the Imperial Institute recommended the adoption, in general, of the suggestions of the Skelton Committee of the Imperial Committee on Economic Consultation and Co-operation, 1933, but suggested the establishment of two separate organisations for dealing with mineral resources and with plant and animal products respectively.

The session dealing with the utilization of the results of research adopted three resolutions. First, as regards information on methods for promoting the utilization of non-patentable scientific and technical results which have been found successful, the Conference desires the appointment of an editor, attached to the British Commonwealth Scientific Office in London, to collect this information and prepare a report for circulation by December 1947. The second resolution recommends the establishment of close co-operation between any organisations established locally to ensure the maximum utilization in the national interest of patentable discoveries, in order that there may be the greatest possible use of patentable discoveries throughout the Commonwealth and Empire. Finally, it was agreed that a practical scheme for a Commonwealth patent would have substantial advantages for technical development in the Commonwealth, but it was realized that technical difficulties may well render such a scheme impracticable; the Conference, therefore, recommended that heads of delegations should discuss with their Governments the desirability of re-examining the whole question.

At the final review session, the Conference adopted resolutions to provide permanent machinery for facilitating scientific collaboration in the Commonwealth and for following up the recommendations of the Conference by establishing a standing committee, with a secretary and 'working party' in London. The standing committee consists of the executive heads of Government organisations for scientific and industrial, agricultural and medical research in the United Kingdom, the Dominions and India, together with three scientific representatives nominated by the Colonial Office. The 'working party' consists of deputies of members of the standing committee with its secretary as chairman, and the overseas members of the standing committee have already indicated that their deputies will be their liaison officers serving in London.

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# OBITUARIES

## Prof. Karl Mannheim

It is quite impossible to estimate the loss which education and scholarship have suffered as the result of the untimely death on January 9 of Karl Mannheim at the early age of fifty-three. Though we have had him with us in Britain for barely fourteen years, his work and influence among us afford a signal example of the gain that accrues to this country from the welcome which, by tradition, it gives to refugee thinkers and scholars. A Hungarian by birth, he held the chair of sociology at the University of Frankfurt when the Nazis came to power. A marked man, he was removed from his post and took refuge in Britain. Here the London School of Economics generously made a place for him.

Distinguished as he was as a sociologist, his deepest concern was for education. To it, guided by well-grounded principle and proceeding in conditions of spiritual and intellectual freedom, he looked as a main instrument for the reconstruction which he knew that Western culture would have to undergo. He spoke often of what he called the 'Middle Way' or the 'Third Way', the *via media* between *laisser-faire* and totalitarianism. It was his conviction that Britain had the mission of demonstrating to the world how that way could be marked out and followed.

Wholly sympathetic to the English spirit, and coming in the fullness of his powers to assimilate and share in it, Mannheim was able to note elements of strength and weakness which were likely to be less apparent to the native-born. It was that, more than anything else, which made his personal influence so immensely valuable. So he was at his best in a seminar, or particularly in a discussion group with intimate friends. Then one saw how the humility and the profound humanity of the man were the sources from which arose the quick understanding, the intuitive sympathy and the infinite teachableness which were so characteristic of him.

In his teaching as in his works ("Ideology and Utopia", "Man and Society in an Age of Reconstruction", and "Diagnosis of our Time"), he claimed

to be attempting no more than diagnosis. What he had of prescription was still for him in the region of fundamental hope and faith, rather than in that of a worked-out programme. Perhaps the latter part of his "Man and Society" could be taken as his formulation of the problem of our time—planning for freedom. As a further contribution to the co-operative study of the crowding problems, he planned the series of monographs which have been appearing in the International Library of Sociology and Social Reconstruction. Under his general editorship, some forty volumes have already appeared, and others are in preparation or projected.

But great and far-reaching as Mannheim's work and influence as a sociologist have been, it is as a teacher that his memory will be most deeply treasured. Those who knew him and realized what he had to bring to British education could not but applaud when, towards the end of 1945, the University of London appointed him to the chair of education at the Institute of Education, where, for some years previously, he had given a lecture course. Students knew his value. "It was always an inspiration to us when he lectured" is a typical comment by one of them.

Irreparable as the loss is, we can yet take some comfort in the belief that his work among us had proceeded far enough to ensure that his influence will abide, and that what he taught us concerning our own mission and destiny will remain to guide us in those trials of the spirit through which we may still have to pass. F. C.

## Prof. L. W. Lyde

THE death on January 24 at his home at Cirencester of Prof. Lionel William Lyde has removed from the active list another of the small band of pioneers who laid the foundations in Britain of the modern concept of geography, and its re-recognition as a subject of university status. Chisholm, Herbertson, Mackinder, H. R. Mill, Marion Newbigin and Lyde each contributed in a different way to this revival; each brought to bear upon the problems of the new sphere of interest a mind trained in other disciplines.

The son of Canon Lyde of Queens' College, Cambridge, Lyde was born on March 28, 1863, and educated at Sedbergh and Queen's College, Oxford, where he held a classical exhibition. Literary and classical studies were the background of his work, and it was his interest in classical history which led him to the study of man in relation to his environment. His first book, "An Introduction to Ancient History" (1890), published when he was English master at Merchiston School, Edinburgh, was followed by two school text-books, "Man on the Earth" (1895) and "Man and his Markets" (1896), which undoubtedly exercised an enormous influence on the school teaching of geography. Lyde was still a comparatively young man when his publishers gave a small dinner to mark the sale of the two millionth copy of his books.

After a period in Glasgow and as headmaster of Bolton Grammar School (1899–1903), he went to University College, London, as professor of geography—in the days when colleges could appoint professors at purely nominal salaries. For many years his students could only qualify for diplomas but, through the efforts of Lyde, H. N. Dickson, A. R. Hinks and others, London instituted an honours degree, and it was Lyde who trained the seven students who were the entrants to the first examination in 1921. He was an inspiring teacher and exercised a great influence over his students. He had marked likes and dislikes—of people, their work and ideas—and he had something of the historian's worship of contemporary sources, which led him to place undue reliance on local scraps of information culled from the most varied sources. "The Continent of Europe" (1913) and "The Continent of Asia" (1933) thus combine wide reading and deep scholarship with both sound and ill-founded deductions. His appreciation of Oriental, especially Chinese, scholarship influenced his own search for an underlying geographical philosophy, and "Peninsular Europe"—a difficult book to read—is an attempt to trace the influence of peninsularity on European history.

When he left University College in 1928, Lyde returned to his old love, the classics, and published a number of books. In all this work he had the sympathy and help of his wife and his two sons.

L. DUDLEY STAMP

# NEWS and VIEWS

## Prof. J. W. Heslop Harrison, F.R.S.

ON September 30, 1946, Prof. J. W. Heslop Harrison retired from the chair of botany in King's College, Newcastle upon Tyne. Since that date, the University of Durham has conferred upon him the title of professor emeritus, so giving due honour to one of her most illustrious north country sons. In 1917 he went to Newcastle, holding a research appointment as a senior investigator under the Department of Scientific and Industrial Research. Later, he became a lecturer in zoology, and in 1926 was elected to a college readership in genetics. In 1927 he was appointed to the chair of botany, when the late Prof. J. W. Bews returned to South Africa. His earliest researches were concerned with biogeography. In particular, they dealt with the flora of Upper Teesdale and Lepidoptera of a bifocal distribution. His genetical and cytogenetical researches commenced with studies in interspecific hybridity and heredity in the Lepidoptera, more especially in the sub-family Bistoninæ and the genus *Oporinia*. Observing the prevalence of melanism in this genus, he studied its incidence, causes and induction in many Geometrid genera. Cytogenetical examinations in the interspecific crosses gave rise to investigations on the relations between chromosomes and phylogeny in the Lepidoptera and thence to the detection of polyploid series in the group—a totally unexpected phenomenon. In considering the effects of natural selection in wild *Oporinia* populations, Prof. Harrison saw possibilities of Lamarckian explanations. Accordingly he planned and carried out experiments (*a*) on the development of inherited, new food habits in the sawflies of the genus *Pontania*, and (*b*) on the production and inheritance of light effects in the pupæ of the butterfly *Pieris napi*. Prof. Harrison's genetical

work on plants began with field observations on wild roses and willows, which led to researches in the cytogenetics of *Rosa* and its hybrids as well as of *Salix*, and the discovery that most British roses are of hybrid origin. In 1934 he commenced his work on the flora and fauna of the Hebrides. From these studies in systematics proceeded intensive studies in the biogeography of the area and in its Pleistocene and Holocene history and geography.

We have been informed that Prof. Harrison hopes to devote much time in future years to research. At present he remains working at King's College, holding for two years a College Research Fellowship, giving lecture courses on genetics and evolution, and supervising postgraduate researches in genetics. We hope that this last phase of his University career will prove as fruitful as all the varied earlier ones have been, and that many happy years are in store for him when he finally withdraws from the walls of his proud and grateful Alma Mater.

## Psychology at Aberdeen : Prof. Rex Knight

THE most recent addition to the number of university chairs in psychology is at Aberdeen, where Mr. Rex Knight has been appointed to the Anderson professorship. Prof. Knight was born at Wilcannia, New South Wales, in 1903, and graduated from the University of Sydney in 1923 and the University of Cambridge in 1925. He was a member of the staff of the National Institute of Industrial Psychology during 1925–28, first as an investigator, then as assistant to the director, the late Dr. C. S. Myers, and co-editor of the Institute's journal. After a year as lecturer at the University of St. Andrews, he was appointed Anderson lecturer (later reader) in psychology at the University of Aberdeen in 1929. During the War, for three years he gave a weekly broadcast commentary for the Ministry of Information, together with numerous lectures for the Central Advisory Council for Education in the Forces in remote parts of Scotland. During 1943–45 he was attached to the War Office staff of the Directorate for Selection of Personnel. His book on "Intelligence and Intelligence Tests" is widely used, and he is well known for his advocacy, in 1932, of the strictly scientific approach to animal psychology (cf. his article in *Nature* of Nov. 9, 1932, on "The Explanation of Animal Behaviour"). But Prof. Knight's main interests are in dynamic and social psychology, the applications of psychology to everyday human problems, its relation to literature and the other arts, and the role of psychology as an ingredient in a general education.

## University of Glasgow

THE Department of Scientific and Industrial Research has offered to supply and erect for the Department of Natural Philosophy of the University of Glasgow a 300 MeV. synchrotron, and to make a capital grant of £3,500 towards the provision of a high-voltage generator. Dr. J. M. Hyslop has resigned his lecturership in mathematics in the University on his appointment to the chair of mathematics in the University of Witwatersrand. Dr. T. S. Stevens has resigned from the Department of Chemistry to become lecturer in organic chemistry in the University of Sheffield ; Drs. Stanley Alstead and R. A. Shanks have resigned from the Department of Materia Medica to become (respectively) medical consultant for the North of Scotland at Inverness and medical registrar at Yorkhill Hospital for Children, Glasgow. Messrs. C. E. Bond, R. Lambert Hurt and A. J. Webster have been appointed assistants in the Department of Anatomy, and Mr. John Higginson an assistant in bacteriology.

## Mechanical Recording of Information

THE system used at the Royal Cancer Hospital to record information numerically about cancer patients so that it can be transferred to a punched card and sorted mechanically is described by D. W. Smithers, K. M. H. Branson and H. O. Hartley in a pamphlet which includes also the instruction book and code book in use (from the Royal Cancer Hospital). This information should be of general interest to the medical research worker and to others who are considering the use of punched cards for bibliographic purposes or statistical analysis. The essential features of the system are the compilation of a special record card from notes on the patient, the information on the card being such that it can be expressed in numerical form and is suitable for rapid analysis by mechanical means. Filling in this card is the only extra clerical work required of the medical man, usually a registrar, beyond his usual duties of keeping accurate notes. The time required for coding and preparing the card for punching is greater, but this work can be carried out by a specially trained clerk. The special record cards remain the property of the hospital and are filed there. Most of the information on these cards can be transferred to a Hollerith punched card by a clerk trained for the purpose and employed by the hospital, or if no such clerk is available they may be sent for punching to the British Tabulating Machine Co., Ltd. As analysis of both standard data and special hospital data is made mechanically, information obtained from the cards can be supplied either to a central organisation, an individual hospital or to any clinician concerned.

The Royal Cancer Hospital and the group of hospitals with which it co-operates are giving the system a preliminary trial for all cancer patients coming under their care from January 1, 1945.

## Abstracts of World Medical Literature

Two new monthly medical abstracting journals, *Abstracts of World Medicine* and *Abstracts of World Surgery, Obstetrics and Gynæcology*, have been published by the British Medical Association. The first (January) issues have now appeared, and even a glance through the pages shows that Dr. Hugh Clegg, editor of the *British Medical Journal*, under whose general direction they are being issued, and Dr. G. M. Findlay, who edits them with the assistance of Dr. S. S. B. Gilder and a panel of advisers, are to be congratulated on both the planning and the execution of the considerable task which they have undertaken. The foreword to both these issues traces the history of recent medical abstracting work, from the Medical Research Council's publication during the First World War, of information derived from medical literature then appearing, to the similar service begun during the Second World War and continued in the form of the *Bulletin of War Medicine*. The success of the latter encouraged the British Medical Association to continue an abstracting service when this bulletin ceased publication in 1946, and the two new journals are the result. They give, over a remarkably wide range, abstracts of articles selected from more than

a thousand periodicals. Comments by the abstractors are printed inside square brackets, so that there will be no confusion between the views of the abstractor and those of the authors of the article abstracted.

The type chosen for the new journals is attractive and clear, and they are so bound that they are pleasant and convenient to use. They form a valuable supplement to the excellent epitomes of British medical literature published in the *British Medical Bulletin*, which was born in 1940 in the editorial department of the British Medical Association as a medical information service to provide, in collaboration with the Ministry of Information, foreign medical journals with surveys of current British medical literature. Later, this service was taken over by the British Council and became, under the able editorship of Dr. Howard-Jones, the *British Medical Bulletin*, which is now an essential feature of medical literature. Medical men all over the world now have, therefore, an information service which should keep them well informed of every important development.

## British Standard Specification for Cable Insulation

A 1946 edition of the well-known British Standard No. 7, the first edition of which appeared in 1904, and which deals with rubber-insulated cables and flexible cords for electric power and lighting, has recently been issued. The main specification, together with a supplement on the use of polyvinyl chloride compounds as an alternative to vulcanized rubber, is published as a single volume (B.S.7; 1946. British Standards Institution, Publications Department, 28 Victoria Street, London, S.W.1. 3*s*. 6*d*., post paid) and an amendment, entitled "Transitory Relaxations", is issued separately in the form of a leaflet (Ref. *PD* 540). War-time conditions hastened the introduction of polyvinyl chloride insulated cables, and this necessitated several modifications to the original specification. The 1946 edition, while retaining in substance all the usual features, makes allowance for the change-over to peace-time conditions. Some of the modifications referred to above are retained as permanent revisions to the specification, others are retained only temporarily, to be dropped eventually, while others have been entirely cancelled. The specification is divided into three sections: the first, of a general nature, defining terms, sizes, etc., used later in the specification; the second, dealing with the construction of the different types of cables and cords; and the third, with tests for thickness of insulation and sheath, voltage, insulation resistance, spark testing, tinning and armouring. The numerous tables with which the specification is provided make the publication an extremely useful one for all users and manufacturers of electrical cables and cords.

## Durban Museum and Art Gallery

ALTHOUGH the annual report of the Durban Museum and Art Gallery for the year ended July 31, 1945, shows their satisfactory maintenance as cultural and educational centres, it points out the need for extensions if these institutions are to function in a manner adequate to the future needs of a city growing in both size and importance. A new building has been embodied in a post-war development scheme, and it is now recommended that this be erected as soon as circumstances permit. Schools continued to make good use of the Museum services during the year. Eighty-nine gallery talks—many of which were augmented by lantern-slide or film shows—were delivered to visiting classes, and the showing of instructional films relating to subjects lying within the scope of the Museum was a regular weekly feature. An interesting departure from the usual type of film shown in museums was one demonstrating the activities of the Durban municipal departments.

## History and Comparative Study of Religion

AN effort is being made to establish in Cambridge a photographic record for use in illustrating the history and comparative study of religions. Any persons, especially those returning from the Services or from the mission field, who may have photographic prints of religious buildings or ceremonies (whether Christian or non-Christian), are invited to send spare copies for this collection. Any contributions will be filed and preserved, with the names of the donors duly recorded. Communications should be sent to the voluntary curator of the record, the Rev. Dr. Bouquet, Gilling House, Madingley Road, Cambridge. It is also desired to register the whereabouts of cinematograph films dealing with the same subjects, especially if in private hands.

## Summer School in Social Biology (Switzerland)

THE British Social Hygiene Council proposes holding a summer school on "Social Biology: its International Aspects", in Switzerland during the last fortnight in August. It is proposed to devote one week to study and the second week to visits, expeditions and recreation. The School is intended for teachers and social workers, and others interested in social biology from Britain, but it is hoped that there will also be students from other countries. Lectures will be in English. The estimated cost, including travel, board and tuition, will be between £25 and £30. Further information can be obtained from the Secretary, British Social Hygiene Council, Tavistock House North, Tavistock Square, London, W.C.1.

## Announcements

MR. S. S. CARLISLE, a graduate of Queen's University, Belfast, has been appointed head of the Instrument Section of the British Iron and Steel Research Association, in succession to Mr. W. C. Fahie, who is taking up an appointment in the Ministry of Defence. Mr. Carlisle joined the Association in October 1946, following four years' service in the Experimental Department, H.M.S. *Excellent*, Portsmouth, on the staff of the Director of Scientific Research, Admiralty, where he was largely responsible for the design and development of certain special recording instruments and electro-mechanical control systems associated with modern gunnery and radar techniques.

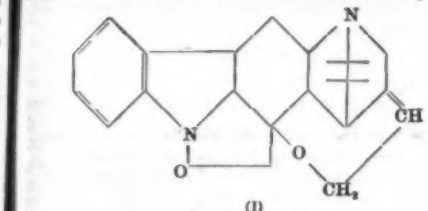
ONE of the activities of the Viking Fund (14 East 71st Street, New York) is the publication, in conjunction with its summer seminar in physical anthropology, of a "Yearbook of Physical Anthropology", which consists, in the main, of reproduction in full of a score of important papers appearing during the year. The yearbook is distributed free of charge to members of the American Association of Physical Anthropologists and to other interested persons. The second issue (for 1946) is now in preparation, and the editor, Dr. Gabriel Lasker, would welcome reprints and references to material which might be considered for inclusion.

# LETTERS TO THE EDITORS

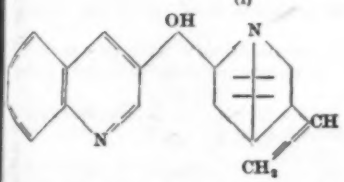
*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

## Constitution of Strychnine and its Relation to Cinchonine

THE progress of experimental studies of strychnine derivatives, especially of neostrychnine, in this Laboratory has shown that no formulation hitherto suggested is adequate. Furthermore, it has not been found possible to modify the structure in a satisfactory manner on the basis of generally accepted deductions in regard to the ring containing the amide group. The validity of the simple and direct explanations of Leuchs' degradation of the strychninolones and brucinolones has therefore become questionable, and feasible alternatives of a more complicated character have been devised. These allow the amide ring to be five-membered, and on this basis an entirely novel and very satisfactory strychnine constitution (I) can be developed. This serves to illustrate the whole chemistry of the alkaloids, including the most recent findings, and must therefore be regarded as the best working hypothesis at present available. It is free from all stereochemical difficulty, and double bonds can be accommodated where necessary.



(I)



Cinchonine

It can be set up on the models in strainless stereoisomeric forms, of which the two most characteristic are those obtained by *cis* and *trans* disposition of the nitrogen atoms in relation to the central *cyclo*hexane ring. The carbon skeleton can be dissected in exactly the same way as was indicated[1] in the case of another formula (with six-membered amide ring), but the relation with cinchonine is now even closer and is at once apparent on comparison of the structures. Speaking only of the carbon–nitrogen skeleton, (I) is cinchonine in which an indole nucleus replaces quinoline, and there are three additional carbon atoms in the amide ring. This is a very striking result, and nothing similar can be achieved by retaining a six-membered amide ring.

The cinchonine formula is depicted in an unusual arrangement to facilitate the comparison with (I).

A fuller discussion and description of relevant experiments will be submitted for publication elsewhere.

R. ROBINSON

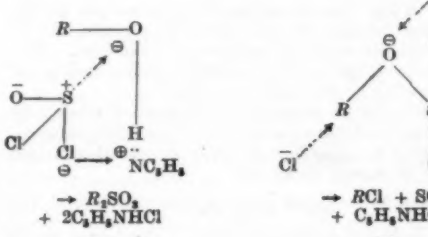
Dyson Perrins Laboratory,
University of Oxford. Jan. 14.

[1] Openshaw, H. T., and Robinson, R., *Nature*, **157**, 438 (1946).

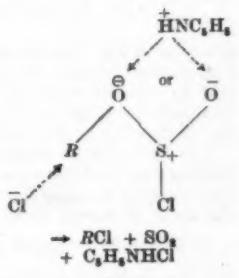
## Influence of Tertiary Bases on the Interaction of Thionyl Chloride and Hydroxy Compounds

IN contrast to the observations of Human and Mills[1] on the use of pyridine in the interaction of thionyl chloride and the carboxylic group, we found that instead of *one* molecular proportion of tertiary base in the Darzens' procedure[2] for hydroxy compounds, much less than 0·1 mol. of base or its hydrochloride was sufficient. Thionyl chloride (1·0 mol.) was added to a cooled mixture of the hydroxy compound (*iso*-amyl, *n*-butyl, β-phenylethyl alcohols, or ethyl lactate) (1·0 mol.), and a few drops of base (pyridine, quinoline, or dimethylaniline) or a small amount of the corresponding hydrochloride. An excellent yield of the chloride (*R*Cl) was distilled directly from the reaction mixture, after it had been heated for four hours at 65–80° (depending on the base). Yields approaching 95 per cent were obtained.

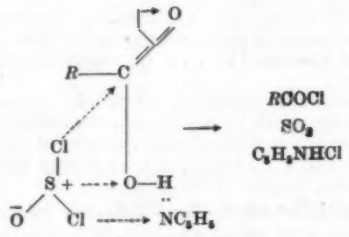
To account for the ease with which thionyl chloride forms pyridine hydrochloride and the sulphite ($R_2SO_3$), it was suggested by one of us[2] that the lone pair of electrons on the nitrogen atom forms a hydrogen bond with the hydroxylic hydrogen, and this facilitates properly orientated 'broadside' collisions (I). The function of the small amount of pyridine hydrochloride in facilitating the decomposition of the intermediate chlorosulphinate (*R*OSOCl) formed in the interaction of thionyl chloride and hydroxy compound may also be due to hydrogen bonding (II), the *R*—O bond being thereby sufficiently weakened to increase the probability of fruitful attack along the 'end-on' direction by such groups as $Cl^-$ or $\bar{O}SOCl$. The ion $C_5H_5NH^+$ is repeatedly regenerated. Certain structural features, such as a phenyl group attached to the reactive centre, may lead to deviations which can only be discussed in detail.



I



II



III

Hydrogen bonding may account for the better results obtained by Human and Mills when they used pyridine in *one* molecular proportion in their experiments with carboxylic acids (III).

W. Gerrard
K. H. V. French

Northern Polytechnic,
Holloway Road,
London, N.7.
Jan. 13.

[1] Human and Mills, *Nature*, **158**, 877 (1946).
[2] Darzens, *C.R. Acad. Sci., Paris*, **152**, 1314, 1601 (1911).
[3] Gerrard, *J. Chem. Soc.*, 688 (1936); 99 (1939); 218 (1940); 85 (1944).

## Absolute Values of the Rates of Unimolecular Reactions

Experimental unimolecular reaction-rates in gases are adequately represented by the equation:

$$K_{\text{uni}} \equiv -\frac{1}{N}\frac{dN}{dt} = a \exp(-E/kT) \text{ sec.}^{-1}, \quad (1)$$

where $N$ is the concentration, $T$ the absolute temperature, and $k$ is Boltzmann's constant. The fact that $a$ is in most cases found to be of the order of magnitude of intramolecular vibration frequencies ($10^{14}$ sec.$^{-1}$) has been much discussed. By an approach akin to that of Polanyi and Wigner[1], I obtained a theoretical reaction-rate in which $a$, although not precisely determined, was of this order of magnitude[2,3]. This result can now be made precise.

The gas molecule is treated (as before) as a classical system with $n$ internal degrees of freedom, and $n$ normal modes of harmonic vibration; the vibration frequencies $\nu_1, \ldots \nu_n$ of these modes are assumed to be linearly independent numbers. The time-variation of a geometrical co-ordinate $q$, such as the extension of an inter-atomic bond, is a sum of normal-mode terms:

$$q = \sum_{s=1}^{n} \alpha_s \sqrt{\varepsilon_s} \cos 2\pi(\nu_s t + \varphi_s), \quad (2)$$

where $\varepsilon_s$ is the energy and $\varphi_s$ the phase-angle in the $s$ th normal mode; on this classical picture, the $\varepsilon_s$ and $\varphi_s$ change only at molecular collisions. The 'amplitude factors' $\alpha_s$ are constants characteristic of the particular co-ordinate $q$ considered.

The molecule is assumed to dissociate when one particular co-ordinate $q$ attains a critical high value $q_0$. This value is attainable only after collision has raised the internal energy to satisfy

$$\Sigma \alpha_s \sqrt{\varepsilon_s} \geqq q_0, \quad (3)$$

but the molecule dissociates only if the terms in (2) have time to come sufficiently into phase for $q$ to reach $q_0$ before further collision removes the high energy. If then $L(\varepsilon_1, \ldots \varepsilon_n; q_0)$ is the frequency with which the sum (2) would attain $q_0$ if undisturbed, $L$ may be taken to represent the proportion of molecules with energies $(\varepsilon_1, \ldots \varepsilon_n)$ which dissociate per second.

At the high pressures at which de-energizing collisions are much more frequent than dissociations, the number of molecules with energies in the ranges $(\varepsilon_1, \varepsilon_1 + d\varepsilon_1) \ldots (\varepsilon_n, \varepsilon_n + d\varepsilon_n)$ is very nearly the equilibrium number, namely,

$$N(kT)^{-n} \exp(-\Sigma\varepsilon_s/kT) d\varepsilon_1 \ldots d\varepsilon_n.$$

A fraction $L$ of these dissociate per second; thus the total dissociation-rate is the first-order rate:

$$K_{\text{uni}} \equiv -\frac{1}{N}\frac{dN}{dt} = \int_0^\infty \cdots \int_0^\infty L(\varepsilon_1, \ldots \varepsilon_n; q_0) (kT)^{-n} \exp(-\Sigma\varepsilon_s/kT) d\varepsilon_1 \ldots d\varepsilon_n. \quad (4)$$

(We can integrate from $\varepsilon_s = 0$, since $L = 0$ where (3) is not satisfied.)

Now

$$L = \tfrac{1}{2} \lim_{\tau \to \infty} \{M(\tau)/\tau\},$$

where $M(\tau)$ is the number of zeros, for $0 \leqq t < \tau$, of $q - q_0$ with $q$ defined by (2). I used before[2] an approximate formula for this limit, but use now a formula due to Kac[4], which gives in our notation:

$$L(\varepsilon_1, \ldots \varepsilon_n; q_0) = \frac{1}{4\pi^2} \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \frac{\cos(q_0\xi)}{\eta^2} \left\{ \prod_1^n J_0(\xi\alpha_s\sqrt{\varepsilon_s}) - \prod_1^n J_0[\alpha_s\sqrt{\varepsilon_s(\xi^2 + 4\pi^2\nu_s^2\eta^2)}] \right\} d\xi d\eta. \quad (5)$$

Inserting this in (4) and integrating first for the $\varepsilon_s$ by means of Weber's formula[5], we find that

$$K_{\text{uni}} = \nu \exp(-q_0^2/\alpha^2 kT),$$

where

$$\alpha^2 = \Sigma\alpha_s^2, \quad \nu^2 = \alpha^{-2}\Sigma\alpha_s^2\nu_s^2. \quad (6)$$

It is easily found that the minimum total internal energy for dissociation, that is, the minimum $\Sigma\varepsilon_s$ satisfying (3), is

$$E_0 = q_0^2/\alpha^2.$$

Thus, finally,

$$K_{\text{uni}} = \nu \exp(-E_0/kT). \quad (7)$$

The factor $\nu$ in this result is, by (6), the root mean square of the vibration frequencies weighted by the amplitude factors $\alpha_s$. It is thus independent of temperature, so that[3] the energy $E_0$ in (7) may be identified with the empirical $E$ of (1) as the 'activation energy'.

A full discussion of this theory, with an extension to low-pressure dissociation-rates, will be given elsewhere.

N. B. Slater

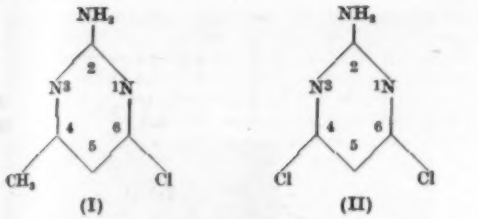
Department of Mathematics,
University, Leeds.
Dec. 27.

[1] Polanyi and Wigner, *Z. phys. Chem.*, A, **139**, 439 (1928).
[2] Slater, *Proc. Camb. Phil. Soc.*, **35**, 56 (1939).
[3] Fowler and Guggenheim, "Statistical Thermodynamics", 529 (1939).
[4] Kac, *Amer. J. Math.*, **65**, 609 (1943).
[5] Watson, "Theory of Bessel Functions", 393 (1922).

## Crystal Structures of 2-Amino-4-Methyl-6-Chloropyrimidine and 2-Amino-4,6-Dichloropyrimidine

A series of investigations on the structures of pyrimidines and purines is being carried out in close association with the work of Prof. A. R. Todd and his collaborators on the chemistry of these and related compounds.

No previous structural work on pyrimidines has been reported in the literature, so an extensive search was made for compounds which seemed likely to permit of a determination of structure without previous assumptions as to the nature of the pyrimidine molecule. Two isomorphous pyrimidines were selected: 2-amino-4-methyl-6-chloropyrimidine (I) and 2-amino-4,6-dichloropyrimidine (II).




(I) (II)

Both compounds crystallize from alcohol as thin laths the lengths of which correspond to the *b*-axis. The monoclinic unit cell has dimensions, $a = 16{\cdot}4$, $b = 3{\cdot}8_3$, $c = 10{\cdot}3$ A., $\beta = 108°$, and the space-group is $P2_1/a$ ($C_{2h}^5$) with four molecules in the cell. The intensities of nearly 200 *hol* reflexions were determined from Weissenberg photographs of both compounds. These intensities were used in the computation of Patterson projections along the *b*-axis, and for the dichloro compound it was possible to determine *x* and *z* co-ordinates for both of the chlorine atoms. Phases could then be assigned to a number of the terms used in a Fourier synthesis which gave a first approximation to the structure. The third approximation is illustrated in Fig. 1.

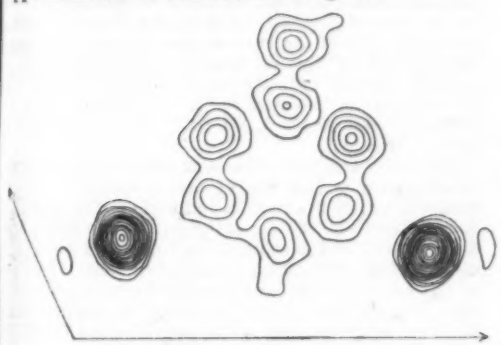


Fig. 1. 2-AMINO-4,6-DICHLOROPYRIMIDINE. ELECTRON DENSITY PROJECTED ON (010). CONTOURS DRAWN AT INTERVALS OF 2·5 ELECTRONS PER A.²

A similar procedure was adopted for the second compound, and the second Fourier projection is shown in Fig. 2. The approximate equality in height of the peaks in the 4- and 6-substituent positions is of considerable interest, as, of course, one of these should be a chlorine atom and the other a methyl group. The heights of the peaks correspond to a group the scattering power of which is the mean of that of chlorine and carbon atoms. This probably indicates that the chlorine atoms and methyl groups are distributed randomly through the structure in either the 4- or 6-positions, and this idea is supported by the Patterson projections. A similar phenomenon was reported for *p*-bromochlorobenzene by Hendricks[1], although in this case the space group ($P2_1/a$ with two molecules in the unit cell) requires a centro-symmetrical molecule.

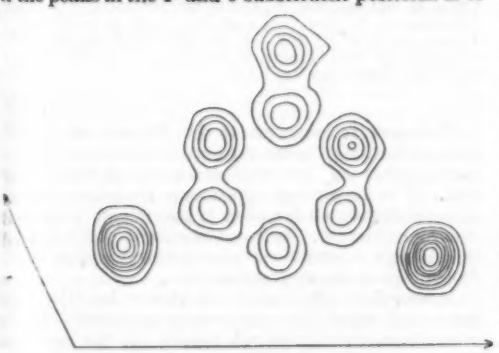


Fig. 2. 2-AMINO-4-METHYL-6 CHLOROPYRIMIDINE. ELECTRON DENSITY PROJECTED ON (010). CONTOURS DRAWN AT INTERVALS OF 2·5 ELECTRONS PER A.²

Although the molecules lie almost in the plane of projection, it is not possible at this stage to give any useful data on bond-lengths and bond-angles. Further work is now in progress, from the results of which it is hoped to derive such information. The structures of *p*-dibromo- and *p*-bromochlorobenzene are also being re-examined with the view of more precise determination.

C. J. B. CLEWS
W. COCHRAN

Cavendish Laboratory,
Cambridge.
Dec. 16.

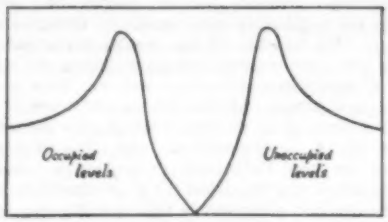
Hendricks, S. B., *Z. Krist.*, **84**, 85 (1933).

## Energy Bands in Graphite

THE graphite crystal is known to consist of parallel planes of carbon atoms. The planes are about 3·35 A. apart, indicating[1] that the binding between them is of long-range, or Van der Waals, type. In each plane the atoms form a regular hexagonal pattern of side 1·42 A. The closeness of this value to that for aromatic systems such as benzene (1·39 A.) or coronene[2] (1·41 A.) makes it clear that in any one plane the binding consists of: (i) basic σ-type bonds resembling ordinary chemical single bonds, symmetrical around each C—C direction, and effectively localized in this region; and (ii) mobile (or conduction, or π-) electrons, which are not localized, and the symmetry of which relative to the basal plane is the same as that of a separate $2p_z$-atomic orbital, the *z* direction lying perpendicular to the plane. The existence of these second electrons gives the metallic character to graphite, and their behaviour may be studied by methods essentially similar to those used[3,3,4] for condensed hydrocarbons. These methods correspond, in usual metal theory, to the 'tight-binding approximation'.

Our first calculations consider the π-electrons in a single plane. These have energies which fall into a band. If we neglect overlap between adjacent $2p_z$-atomic orbitals, this band has symmetry around its mid-point. The accompanying figure shows the density $N(E)$ of energies $E$. The complete band accommodates two electrons per atom. As there is only one π-electron per atom available, the band is exactly half filled.

The most interesting point about this $N(E)$ curve is the fall to zero value in the middle. In fact, the curve resembles that for an insulator, but with a zero-energy gap between the allowed bands. It shows that, in its basal plane, graphite may be called a true electronic semi-conductor. At absolute zero of temperature, the lower half of the complete band is completely filled, and the upper half completely empty. As the temperature increases above zero,




electrons get into the upper half, but only in small numbers, and conduction is possible. Such conduction increases with temperature. All this is in agreement with known experimental behaviour.

Our calculations, which will be reported more fully elsewhere, have been extended to include the previously neglected overlap integral, and to take account of interaction between the separate graphite planes. The general results described above are not significantly altered.

C. A. COULSON

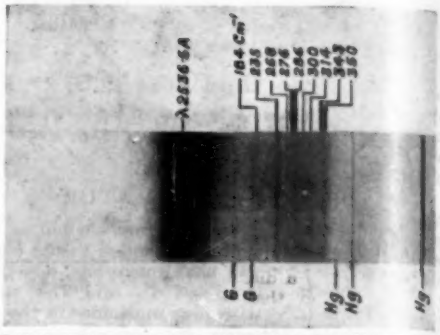
Physical Chemistry Laboratory,
Oxford. Dec. 25.

[1] Lennard-Jones, J. E., *Trans. Faraday Soc.*, **30**, 58 (1934).
[2] Coulson, C. A., *Nature*, **154**, 797 (1944).
[3] Lennard-Jones, J. E., and Coulson, C. A., *Trans. Faraday Soc.*, **35**, 811 (1939).
[4] Bradburn, M., Coulson, C. A., and Rushbrooke, G. S., *Proc. Roy. Soc. Edin.*, in the press.

## Raman Spectrum of Rock-Salt Under High Resolution

THE original investigation of Rasetti[1] as well as my later work[2] on the Raman effect in rock-salt were carried out using a Hilger medium-size quartz spectrograph for recording the faint second-order spectrum. In view of the fundamental importance of the case, it appeared desirable to re-investigate the subject, using the largest possible resolution and dispersion. Various improvements in experimental technique, including especially the efficient filtering of the exciting radiation before its entry into the spectrograph, steady running conditions of the arc and the temperature control of the spectrograph, have enabled me to work with the larger Hilger *E*1 quartz spectrograph for recording the Raman spectrum. Using a fine slit which necessitated an exposure of 160 hours, a record was obtained in which the details are not sensibly obscured by halation and which exhibits the true nature of the spectrum unambiguously.

It will be seen from the reproduction that the spectrum exhibits a set of discrete Raman lines clearly resolved from each other. The positions of the nine prominent lines with their frequency shifts in wave-numbers from the exciting line are indicated above the reproduction. The line with the frequency shift of 235 cm.$^{-1}$, to the sharpness of which Rasetti[1] directed attention in his original investigation, continues to be sharp even under high resolution. The width of this line does not exceed 3 wave-numbers if due allowance is made for the effect of instrumental and photographic factors. Its intensity is more than ten times that of the background on either side. On the longer wave-length side of this prominent line, there is an exceedingly fine line with the frequency shift of 258 cm.$^{-1}$ which is clearly discernible against the background. The intense lines with frequency shifts 300 and 314 cm.$^{-1}$ are also fairly sharp. The pairs of lines with frequency shifts




RAMAN SPECTRUM OF ROCK-SALT TAKEN WITH A HILGER *E*1 QUARTZ SPECTROGRAPH

276, 286 cm.$^{-1}$ and 343, 350 cm.$^{-1}$ have a finite width, but small compared with the width of the peaks in the Born-Bradburn theoretical intensity distribution curve[3].

It may be remarked that in many crystals, for example, diamond[4], quartz[5], calcite[6], etc., the Raman lines which appear extremely sharp at ordinary temperatures broaden to varying extents at higher temperatures. It may therefore be presumed that in the case of rock-salt as well, the observed differences in width of the various lines at room temperature are due to thermal agitation in the crystal. It appears also not unlikely that if the spectrum could be successfully recorded with the crystal held at liquid air temperature, all the lines would appear extremely sharp.

The main conclusion that emerges from the present investigation is that the vibration spectrum of the rock-salt lattice in the infra-red region of frequencies as manifested in the second-order Raman effect is a discrete one, and is different in its nature from that deduced from the lattice dynamics of Born. In view of the results of the present experimental investigation, it does not appear necessary for me to offer any further comments on the points raised by Born[7] in his recent communication in *Nature*.

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THE new photograph of the Raman spectrum of rock-salt seems to me no improvement on previous work, either on that of Rasetti or of Krishnan himself. The dispersion appears to be larger, but not the resolution, so far as it is possible to judge from the reproduction. As no photometric curve is given, Krishnan's contentions about the breadth of the 'lines' are without foundation.

A complete account of the theory by Miss Bradburn and myself has meanwhile appeared[1]. It does not claim to explain all details of the spectrum, because of the simplifications and approximations which were necessary to make the problem tractable. For example, we have replaced the thirty-six branches of the rigorous formula by eighteen, omitting some

and merging others. Further, we have neglected factors depending on the frequency, which may easily shift a maximum by 10 per cent of its wave-number, and we have chosen a few intensity factors in such a way that the aspect of the spectrum as a whole is correct, without considering detailed agreement. Thus the 'line' 235 cm. which Krishnan finds particularly sharp could be easily accounted for by giving our branch 9 a different amplitude.

If Krishnan would attack our method of approximation and our wholesale simplifications, I should raise no objection apart from asking him to make it better. But his conclusion that "the second-order Raman effect is a discrete one, and is different in its nature from that deduced from the lattice dynamics of Born", shows that he does not understand the theory, which is a straightforward application of quantum mechanics.

I do not intend to continue this discussion.

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## Diffraction of Light by High-Frequency Ultrasonic Waves

Recently diffraction patterns have been produced in this laboratory[1] by using ultrasonic waves of frequencies higher than 100 Mc./sec. At such high frequencies, the patterns show some interesting features. Progressive waves of frequency 102·6 Mc./sec. and maintained in water have been employed. When the sound wave is exactly normal to the incident light, the diffraction pattern disappears altogether. On tilting the crystal holder to one side or the other, so that the light rays meet the sound wave-front at an angle of 52′, the first-order diffraction line alone on the appropriate side is obtained. This angle agrees closely with the value derived from the equation $\lambda/\lambda^* = 2\mu \sin\theta$, where $\lambda$ and $\lambda^*$ are the wave-lengths employed and $\mu$ is the refractive index of water. In no position of the sound wave-front has it been possible to get the first-order line on both sides at the same time. The value of the above angle for which the first-order line attains the maximum intensity is quite critical. Even a slight variation of about 2′ has been found to reduce its intensity to half. Thus the diffraction effect at such high frequencies ($\lambda^* = 0{\cdot}00148$ cm.) appears to be very much like reflexion in the Bragg sense.

Contrary to the above results, we have found that patterns at 50 Mc./sec. show the presence of both the first-order lines for normal incidence. For oblique incidence, the first-order line on the appropriate side increases in intensity as the wave-front is tilted and attains a maximum at the corresponding reflexion angle. The first-order line on the opposite side decreases in intensity but does not vanish altogether, showing that the range of reflexion is not so sharp as in the previous case.

Bär[2], Parthasarathy[3] and others have shown that similar phenomena make their appearance, but in a less pronounced manner, at ordinary frequencies such as about 20 Mc./sec. Our investigations show that when 100 Mc./sec. is reached, the well-known features of diffraction are suppressed and the effect simulates reflexion very closely. It may be mentioned here that Nath[4] had shown that the first order would be dominant over the higher ones in the very high frequency region. Our observations are in conformity with this view.

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Dec. 20.

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## Dimensional Changes Accompanying Capillary Condensation

Banks and Barkas[1] have recently directed attention to the mechanical interaction between capillary condensed liquid and the walls of the pores containing it, and they deduce that under certain conditions the pores may collapse when the vapour pressure over the system is lowered. However, when capillary condensation occurs, the liquid condenses on an adsorbed film—not on a bare surface—and it is to be expected that when the vapour pressure is sufficient to cause condensation of liquid, there will always be present an adsorbed film which is *mobile*. A mobile film exerts a pressure[2] numerically equal to the free-energy lowering per unit surface due to its adsorption, and in a capillary tube this pressure opposes the tension of the condensed liquid. Effects due to the pressure of a surface film have been neglected by Banks and Barkas in their calculations.

The role of the film pressure in this kind of problem may be seen by considering the dimensional changes accompanying adsorption and capillary condensation in a cylindrical cavity with very thin elastic walls. If the cavity is originally *in vacuo*, on adsorption of a vapour the film pressure $\varphi$ stretches the walls of the cylinder. Changes in radius may be examined by considering the forces acting across a plane containing the axis of the cylinder. At equilibrium there is no net force acting over any imaginary plane cutting an isolated system, so that after adsorption the circumferential tension in the wall of the cylinder is equal and opposite to the film pressure $\varphi$, or $k\frac{(r_1 - r_0)}{r_0} = \varphi$, where $r_1$, $r_0$ are the new and original radii and $k$ is related to the elastic constants of the material. (When the expansion is large $k$ may depend on the expansion; for present purposes it is treated as a constant.) Similarly, the cylinder will increase in length until the total longitudinal tension in the walls balances the longitudinal force ($2\pi r_1\varphi$) of the adsorbed film.

When capillary condensation occurs, the wall of the cavity becomes wetted by liquid and the surface pressure increases to $\varphi + \gamma\cos\theta$, where $\gamma$ is the surface tension of the liquid and $\theta$ is the contact angle.

(*a*) *Changes in Radius.* Supposing the radius to remain constant at $r_1$, the forces acting over the plane containing the axis of the cylinder would be (i) the tension in the walls $k\frac{(r_1 - r_0)}{r_0}$, (ii) the film pressure $(\varphi + \gamma\cos\theta)$, and (iii) the tension in the condensed liquid. This last quantity is $\frac{2\gamma\cos\theta}{r_1} \times 2r_1 \times 1 = 4\gamma\cos\theta$ per unit length, and the total expansive force per unit length acting across the plane would be

$$-2k\frac{(r_1 - r_0)}{r_0} + 2(\varphi + \gamma\cos\theta) - 4\gamma\cos\theta,$$

which is not zero. Therefore, at constant vapour pressure, the cylinder would *shrink* to a new radius $r$ determined by

$$-2k\frac{(r-r_0)}{r_0}+2(\varphi+\gamma\cos\theta)-2r\frac{2\gamma\cos\theta}{r_1}=0,$$

or, since $\varphi=k\frac{(r_1-r_0)}{r_0}$, then $\frac{\gamma\cos\theta}{\varphi}=\frac{r_1(r_1-r)}{(r_1-r_0)(2r-r_1)}$.

(*b*) *Changes in Length.* On condensation at the radius $r_1$, the longitudinal expansive force due to the film pressure would increase by $2\pi r_1\gamma\cos\theta$, but the tensile force of the liquid would be $\frac{2\gamma\cos\theta}{r_1}\times\pi r_1^2$, that is, it would be equal and opposite the increased expansive force of the adsorbed film. Therefore, if the radius remained constant on capillary condensation, there would be no tendency for the length of the cavity to alter. It follows that there would be no dimensional change accompanying condensation in a *spherical* cavity.

However, due to the radial shrinkage from $r_1$ to $r$, the longitudinal expansive force is reduced from

$$2\pi r_1(\varphi+\gamma\cos\theta) \text{ to } 2\pi r(\varphi+\gamma\cos\theta);$$

while the longitudinal tensile force of the liquid is reduced by

$$\pi(r_1^2-r^2)\frac{2\gamma\cos\theta}{r_1}.$$

The net decrease in the expansive force is then

$$2\pi(\varphi+\gamma\cos\theta)(r_1-r)-\frac{2\pi\gamma\cos\theta}{r_1}(r_1^2-r^2),$$

which reduces to

$$\frac{2\pi(r_1-r)}{r_1}\{r_1\varphi-r\gamma\cos\theta\}.$$

Consequently, on capillary condensation, the length of the cavity will decrease, remain constant, or increase according as $r_1\varphi$ is greater than, equal to, or less than $r\gamma\cos\theta$.

These examples illustrate the primary role of the film pressure $\varphi$ as an influence on the dimensional changes accompanying adsorption. Moreover, the difference between the longitudinal and transverse effects emphasizes the importance attaching to the geometry of the deformable system. The difference between the *form* of the above equations for the radial changes and the equations of Banks and Barkas arises merely from the supposition made above that the wall of the capillary is very thin. For a wall of finite thickness, more complicated equations analogous to those of Banks and Barkas but containing an additional term due to the film pressure would be obtained. It will be noted that on slightly lowering the pressure after capillary condensation has occurred, the reduced radius will cause the liquid to remain in the capillary, that is, the radial shrinkage leads to a hysteresis in the adsorption isotherm.

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[1] Banks and Barkas, *Nature*, **158**, 341 (1946).
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## Binocular Colour Combinations

Interest centres round the possibility that a good yellow might be made from a binocular combination of red and green, one colour presented to each eye. According to Walls, "There is no color-sensation which can be produced by mixing two lights in one eye, that cannot be duplicated by supplying two lights, independently, one to each eye"[1]. He also puts forward an interesting theory that all colour syntheses, whether monocular or binocular, take place in a single locus, believed to be the lateral geniculate nucleus (whereas fusion of binocular stereoscopic patterns may take place in the lamina of the striate area of the visual cortex)[2].

Two colours, one supplied to each eye, may be combined by means of a simple stereoscope fitted with a colour-filter holder in place of the usual stereoscopic double picture. One colour will stimulate each eye independently.

In experiments of this kind, carried out on eleven subjects with normal colour vision, the eight Ilford monochromatic filters were used, together with Ilford Micro No. 6—a suitable purple. The nine colours were combined binocularly in pairs, starting with red on the left and taking each other colour in turn on the right; then placing orange on the left, and taking each colour except red on the right, and so on, until finally purple was combined with violet. In order to compensate for the effect of the dominant eye, whichever it was, the experiment was then repeated with the sides reversed.

The degree of combination was estimated on a ten-point scale, 0 being complete absence of combination and 1·0 being perfect fusion. Five intermediate points were used: 0·1, 0·3, 0·5, 0·7 and 0·9, in order to simplify the task and also because no colour pair completely failed to fuse or gave perfect combination. The estimates were entered in order in a 9 × 9 table, like a correlation table, and the diagonal cells were then filled with 1·0's, because they represent fusion of each colour with itself, which is always perfect.

Such a table may be factorized by the simple summation method of Burt[3], and the following factor loadings were obtained from an experiment with an experienced observer with normal colour vision.

| Colours combined | General factor | First bipolar | Second bipolar |
|---|---|---|---|
| Purple | 0·648 | −0·247 | +0·723 |
| Red | 0·735 | −0·589 | +0·197 |
| Orange | 0·765 | −0·580 | −0·076 |
| Yellow | 0·867 | −0·402 | −0·349 |
| Yellow-green | 0·839 | −0·089 | −0·676 |
| Green | 0·765 | +0·145 | −0·641 |
| Blue-green | 0·854 | +0·638 | −0·158 |
| Blue | 0·706 | +0·551 | +0·399 |
| Violet | 0·618 | +0·573 | +0·599 |

The general factor shows that all colours have a strong combining tendency when presented independently one to each eye in pairs. The bipolar factors show that there are decided limitations in the ways these combinations can be made. Both bipolars show that complementaries are very difficult to combine, and the second bipolar shows clearly that bright colours are difficult to combine with dark.

Red and green can be combined to a certain extent, under the conditions described, but only with considerable difficulty, and little or no support for the Young–Helmholtz theory will be found in this experiment. It clearly supports a four-colour theory of the Hering or Houstoun type, in which opposite colours would be expected to combine by a 'neutralizing' process in one eye, but not when presented separately to the two eyes, whereas neighbouring colours would be expected to combine readily in either way, which they do.

The fact that complementary colours are extremely difficult to combine when presented separately one to each eye, but very easy to combine in one eye alone,

also throws doubt on the theory that all colour combinations take place in a single locus of the brain, and not in the retina. It is more likely that complementaries combine in the eye, though neighbouring colours may combine in the brain.

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[3] Burt, C., "Factors of the Mind" (1940).

## Social Science in the Gap between the Royal Society and the British Academy

To which of the two above-named august institutions should research workers in social science look up for recognition, guidance, grants-in-aid, expert criticism, and publication? The recent Clapham Report[1], on the Provision for Social and Economic Research, was drawn up by a committee of nine whose qualifications included three F.B.A., three Litt.D., two Ll.D., one D.Sc., but no F.R.S. This literary preponderance suggests that the appropriate body is the British Academy. But a surer guide is a comparison of publications. Those of the British Academy, though full of literary grace and social interest, scarcely contain any quantitative analysis. I doubt if a correlation coefficient could be found anywhere among them. An article in celebration of Leibniz[2] does not contain any mathematical symbols. On the other hand, the publications of the Royal Society, though full of quantitative analysis, scarcely contain any direct mention of human social relations. To which body should a quantitative analysis of a social problem, therefore, be offered for publication? Apparently to neither. There is thus an awkward gap at the highest level of authority. No such gap was intended when the British Academy was formed[3] in 1902. One of its presidents, Sir Frederic Kenyon, in his presidential address on July 4, 1918, said of academies of learning: "Their normal formation is in two classes, one comprising what we now commonly call humanistic studies, i.e., history, philosophy and philology (in the widest sense of the latter term), the other mathematics and natural science. . . . In this country the Royal Society corresponds to one of these classes. The British Academy was founded to play the other part." Since 1902 social science, like other sciences before it, has become more statistical, more quantitative, more mathematical. To give only one example: there are now many published researches on the intelligence of school-children, and on its correlations with their parentage and other social conditions. The results are important for planning, and their discussion involves matrix algebra[4]. So a gap, unsuspected in 1902, has now opened wide. Fortunately the gap is bridged by a number of specialized societies and journals publishing severally statistics, psychology and economics. In the history of science some of the papers printed in specialized journals have turned out to be quite as important as those printed by the Royal Society; for example, Karl Pearson's $\chi^2$ test appeared in the *Philosophical Magazine* for 1900. Nevertheless, a gap remains, because the specialized societies lack the breadth and the general authority of the senior bodies.

I have here emphasized only one of the aspects of a problem which has been explored in general by a Committee[5] on Scientific Research on Human Institutions appointed by the British Association. Reference should also be made to the review[6] of the Clapham Report by Prof. P. Sargant Florence.

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## Relationships between the Assemblages of Plants Fed Upon by Different Insects, and between the Assemblages of Insects that Feed Upon Different Plants

IN the course of a recent investigation of the food-plants of the Chrysomelidæ, a family of about 27,000 species of phytophagous beetles, I have tabulated all available records in relation to the systematic groups simultaneously of the beetles and of the food-plants concerned. The results of this investigation have not yet been published, but they lead me to consider that it would be of interest to investigate the extent to which the following propositions are true for insects in general:

If insects of any given species can feed on plants of more than one species, then insects of any other species that can feed on any of these plant species can feed on all these plant species.

If plants of any given species are fed upon by insects of more than one species, then plants of any other species that can be fed upon by any of these insect species can be fed upon by all these insect species.

*A priori*, these propositions are suggested by analogy. It is at once apparent that they cannot be true without exception, if only because it is known that changes in food-habit are possible in Nature. Moreover, it is an empirical fact that exceptions are observed. Nevertheless, my work on the food-plants of the Chrysomelidæ indicates that these propositions contain a sufficiently large element of truth to be of service in this family as standards for comparison, as bases for prediction, and as indications of possible directions for further observation.

I should welcome the comments of other workers on the extent to which these generalizations are found to be valid and useful in other groups of insects.

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## Allometry of the Vertebrate Brain

FIFTY years ago, Dubois[1] investigated the relationship between the brain and body-weights of certain mammals. Continuing the work of Snell[2], he adopted an expression of the form

$$y = bx^{\alpha} \qquad (1)$$

to describe this relationship, where $x$ is body weight, $y$ is brain weight and $\alpha$ and $b$ are parameters to be determined from the observations; $\alpha$ was termed the phylogenetic constant and $b$ the cephalization constant.

Similar results were obtained by Lapicque[3], and the investigation was continued by Girard[4], by Dubois himself[5], and later by Brummelkamp[6]. A considerable number of papers has appeared, and summaries of the results have been given by Ariens Kappers[7] and de Beer[8].

The conclusions of Dubois and his successors may be briefly stated: (1) The phylogenetic constant, $\alpha$, is invariable for groups of adult animals of different species within a genus or family and has the value 0·56. (2) When adult animals of different sizes but belonging to the same species are considered, the value of $\alpha$ is 0·26. This intra-specific coefficient is known as the ontogenetic constant. (3) The cephalization coefficient, $b$, is always an integral multiple of $\sqrt{2}$ (Brummelkamp).

Dubois transformed his formula into the form

$$\log y = \log b + \alpha \log x, \qquad (2)$$

and writing

$$\alpha_{ij} = \frac{\log y_i - \log y_j}{\log x_i - \log x_j} \quad (i,j = 1, 2 \ldots n) \quad (i > j)$$
$$= \alpha_q$$

he then selected 'suitable' pairs of values, say $k$ ($k < n$), calculated the $\alpha_q$ for each pair ($q = 1, 2, 3 \ldots k$), and finally put

$$\alpha = \frac{1}{k} \sum_{q=1}^{k} \alpha_q.$$

He found that the value of $\alpha$ was approximately 0·56.

This method was ultimately used for a number of groups of animals in order to find both the phylogenetic and ontogenetic constants. Afterwards, the value 0·56 was substituted back into the equation and treated as a kind of universal constant; given $y$ and $x$, $b$ could then be readily calculated. Various hypotheses as to the magnitude and relationships of the cephalization coefficients were then elaborated.

There is little need to point out the inadequacy of such a method of estimating parameters, and von Bonin[9] saw clearly that such a choice of 'suitable' values begged the whole question of cephalization and the development of higher mental qualities. Moreover, it is obvious that it is impossible to make any comparisons between different values of the parameters since no significance tests could be derived.

During the course of an investigation into the growth and organisation of the vertebrate brain, I have had occasion to consider this allometric formula. The values of the parameters and their standard errors may be estimated by maximum likelihood methods from either of the two forms of the equation (1) and (2). If the logarithmic form is used, the normal equations should be suitably weighted, which, so far as I am aware, has not been adequately recognized up to now. I have, in fact, considered the regression of $\log y$ on $\log x$ and used $y^2$ as a weighting factor. The justification for the use of this factor will be discussed elsewhere. I have applied this method to the data available to the authors cited—usually to the figures quoted in their papers. It is a little difficult always to decide upon what principle the data were chosen from Hrdlička and Weber, but I have made use of these data with the addition of some observations from Spitzka[10] for the *Macaca* species. It may be noted that frequently mean values of an unspecified number of observations have been used by previous authors as if they had the validity of the observations themselves.

My results are summarized in the accompanying table.

| Group of animals | Number in group | Value of $a \pm$ standard error | Value of $b \pm$ standard error |
|---|---|---|---|
| Reptiles | 20 | 0·58 ± 0·13 | 0·014 ± 0·05 |
| Birds | 25 | 0·37 ± 0·004 | 0·69 ± 0·02 |
| Primates | 40 | 0·38 ± 0·0002 | 5·3 ± 0·02 |
| Rodents | 32 | 0·62 ± 0·005 | 0·12 ± 0·002 |
| Between Sciuridæ | 35 | 0·60 ± 0·006 | 0·20 ± 0·005 |
| Between Muridæ | 9 | 0·51 ± 0·04 | 0·10 ± 0·02 |
| Within Sciuridæ: | | | |
| *S. rufiventer* | 5 | Not significantly different from zero | 8·96 ± 0·28 |
| *S. carolin* | 17 | | 7·60 ± 0·84 |
| *S. hudson* | 7 | | 4·10 ± 0·17 |
| *Sciuropt. volans* | 6 | | 1·96 ± 0·08 |
| Between *Macaca* spp. | 75 | 0·18 ± 0·0001 | 21 ± 0·001 |
| Within *Macaca* spp.: | | | |
| *M. cynomolgus* | 5 | Not significantly different from zero | 58·5 ± 5·8 |
| *M. nemestrinus* | 8 | | 112·9 ± 11·2 |
| *M. pileatus* | 9 | | 63·7 ± 5·1 |
| *M. rhesus* | 53 | | 80·0 ± 10·5 |

It will be seen that the value of the inter-specific (phylogenetic) constant, $\alpha$, varies widely from the value 0·56. Even in such closely related animals as the Sciuridæ and Muridæ, it can be shown that the values are significantly different.

For all those species which I have considered, the intra-specific (ontogenetic) constant differs from 0·26 and, in fact, does not differ significantly from zero. This implies that if we are justified in fitting an equation of this form, the brains of adult animals of the same species have weights which only vary by random amounts.

In view of these results it would appear that Brummelkamp's hypothesis as to the relationship between cephalization coefficients is untenable.

I must emphasize that I do not consider these data to be adequate for the foundation of hypotheses concerning the quantitative organisation of the brain and the appearance of the higher mental activities in phylogeny or ontogeny. I am inclined to think that the values of parameters estimated from large groups of very different genera, for example, rodents, are of very little interest.

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## Dart of an Extinct Mollusc

The dart in most Belogona is a fragile structure, and although no more perishable than other small calcareous bodies it does not seem to have been found with any frequency as a fossil.

The portion of dart illustrated here is that of the extinct sub-fossil form of *Cepæa nemoralis* L. which occurred in sand dunes at Dog's Bay, Co. Galway, prior to the erosion of the deposit. The mollusc has been referred to the var. *pura* Westerlund (= *ponderosa* Malm.), and a close relative still exists in the Dartry Mountains, Co. Sligo. The fragment, comprising the tip and about a third of the shaft, was

DART OF *C. nemoralis pura* WEST. × *c.* 6

found by sifting material scraped out of a batch of sub-fossil shells sent me by A. W. Stelfox, collected in 1909. It is interesting, in view of the suggested relationship of this form to *C. tonnensis* Sandberger, to notice that the dart is closely similar to that of the living typical *nemoralis*, although it is rather larger.

I can find no previous record of any dart recovered from sub-fossil material. It might be worth searching for more, and it seems possible that careful X-ray examination of palæontological specimens might provide some evidence of the nature of the dart in other extinct forms.

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## Detoxicating Effect of Verdoperoxidase on Toxins

A GREEN ferment with peroxidase activity named 'verdoperoxidase' was isolated from leucocytes in 1941, the amount present in cells being estimated as 1–2 per cent[1]. Verdoperoxidase seems to be located in the eosinophile granules, for Neumann[2] showed that eosinophile granules prepared by tryptic digestion of leucocytes were greyish-green in colour and had peroxidase activity.

The localization of verdoperoxidase and the remarkably high content of the ferment in the leucocytes have led me to undertake investigations to ascertain whether it has a special function in combating infectious diseases. Such an assumption is supported by several earlier observations. In severe infectious diseases, the oxidase granules in the polymorphnuclear leucocytes disappear. Injections of oxone (oxidases and peroxidases) from leucocytes and bone-marrow[3] prolonged by a day or so the life of animals infected with *Ty. mur.*, *B. antrax* and *B. recurrens*. According to Kojima[4], phenol is oxidized by peroxidase and hydrogen peroxide to form a substance with bactericidal action. Petherick and Singer[5] studied the detoxication of bactericidal toxins by metal catalysts. In cases of infectious diseases, Möllerström[6] found an increase in the peroxidase content of the blood-plasma. This increase he considered to be due to a release of peroxidases from leucocytes upon their disintegration.

Experiments have now been performed in order to ascertain whether bacterial toxins could be detoxicated by verdoperoxidase in the presence of peroxides. The most suitable peroxide concentration for the verdoperoxidase action is not yet known. At that concentration, 0·0015 *N*, which is used in the determination of the purpurogalline number of the verdoperoxidase, the ferment is gradually inactivated. The experiments described below were therefore arranged in such a way that the hydrogen peroxide content in a mixture of toxin and verdoperoxidase was gradually increased by dialysis up to the concentration 0·001 *N*. In these preliminary experiments dialysis continued for 24 hours; inactivated verdoperoxidase was replaced by additional amounts of fresh ferment after 6, 12 and 18 hours.

Ten ml. of diphtheria toxin were mixed with 0·35 mgm. verdoperoxidase in a 'Cellophane' bag and dialysed for 24 hours against a solution containing NaCl 0·7 per cent, $Na_2HPO_4/KH_2PO_4$ *m*/150 *p*H 7·4, and $H_2O_2$ *N*/1,000. Temp. 20° C. After 6, 12 and 18 hours 0·20 mgm. verdoperoxidase was added.

From experiments on animals it appears that toxin treated in this way was detoxicated (see Table 1). In order to make sure that this detoxication was due to the peroxidase effect of the ferment, the following control experiments were carried out:

(1) Diphtheria toxin mixed with 0·20 mgm. crystalline horse radish peroxidase and diphtheria toxin alone were dialysed as described above.

TABLE 1. TIME OF DEATH IN HOURS. THE ANIMALS WERE OBSERVED EVERY THIRD HOUR DURING THE FIRST TWO DAYS AND THEN TWICE A DAY

| Toxin concentration | Diphtheria toxin + verdoperoxidase + hydrogen peroxide | Diphtheria toxin + peroxidase + hydrogen peroxide | Diphtheria toxin + hydrogen peroxide | Diphtheria toxin + verdoperoxidase | Diphtheria toxin + peroxidase | Diphtheria toxin |
|---|---|---|---|---|---|---|
| 1/10 | Both alive | Both alive | 18 21 | 24 27 | 21 24 | 18 21 |
| 1/30 | ,, | ,, | 27 30 | 27 33 | 27 36 | 24 27 |
| 1/100 | ,, | ,, | 36 40 | 42 48 | 33 40 | 30 40 |
| 1/300 | ,, | ,, | 56 72 | 48 64 | 72 96 | 72 104 |
| 1/1000 | ,, | ,, | 96 alive | 144 alive | Both alive | 168 alive |
| 1/3000 | ,, | ,, | Both alive | Both alive | ,, | Both alive |

TABLE 2. TIME OF DEATH AFTER INJECTIONS, IN DAYS

| Toxin concentration | Tetanus toxin + verdoperoxidase + hydrogen peroxide | Tetanus toxin + peroxidase + hydrogen peroxide | Tetanus toxin + hydrogen peroxide | Tetanus toxin + verdoperoxidase | Tetanus toxin + peroxidase | Tetanus toxin |
|---|---|---|---|---|---|---|
| 1/30 | All alive | All alive | 3; 3; 3 | 3; 3; 4 | 3; 3; 3 | 2; 2; 3 |
| 1/100 | ,, | ,, | 3; 4; 4 | 4; 4; 4 | 4; 4; 4 | 2; 3; 3 |
| 1/300 | ,, | ,, | 5; 5; 5 | 4; 5; 7 | 6; 6; 7 | 3; 4; 5 |
| 1/1000 | ,, | ,, | 5; 6; 8 | 6; 6; 7 | 7; 8; 10 | 5; 5; 6 |
| 1/3000 | ,, | ,, | Alive, 7; 11 | Alive, 8; 10 | 8; 8; 11 | 7; 9; 10 |
| 1/10000 | ,, | ,, | All alive | All alive | All alive | All alive |

(2) Toxin + verdoperoxidase, toxin + horse radish peroxidase, and toxin alone were dialysed against a solution of the composition described above, but without any hydrogen peroxide. Peroxidase has a purpurogalline number 10–20 times higher than that for verdoperoxidase, and the amount of the former used, 0·20 mgm., was thus somewhat greater than the equivalent of the latter; but it was not necessary to make any further addition of the peroxidase during the experiments.

The dialysed solutions were diluted 10, 30, $10^2$, $3 \times 10^2$, $10^3$ and $3 \times 10^3$ times, and 2 ml. of these diluted preparations were injected subcutaneously into guinea pigs. Two animals were used for every dilution. Table 1 shows how long the animals lived after the injections.

Experiments with tetanus toxin have been carried out in the same way as those described above for diphtheria toxin. The toxin was diluted 30, $10^2$, $3 \times 10^2$, $10^3$, $3 \times 10^3$ and $10^4$ times. 0·5 ml. of the diluted preparations were injected in the caudal veins of mice weighing 14–15 gm. Three animals were used for every dilution. The results are shown in Table 2.

These experiments show that, together with hydrogen peroxide, peroxidases detoxicate diphtheria and tetanus toxins. This is probably one of the functions of verdoperoxidase in the organism. The toxin preparations were not purified, so it is possible that the preparations contain substances which after oxidation inhibit the action of the toxin. It is, however, more probable that the toxin itself contains an oxidizable group responsible for the toxicity.

Experiments are being carried out to ascertain whether the immunizing effect persists for the toxins treated in the manner described above, whether verdoperoxidase can inhibit the toxic effects in animals injected with active toxins, and whether also other toxins may be detoxicated.

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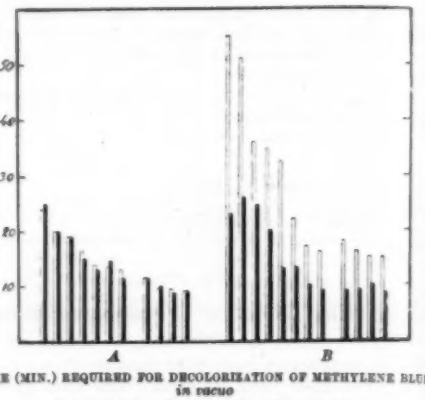
## Curative Effects of a Complex Choline Compound on the Impaired Metabolism of Choline-deficient Rats

IN a previous note in *Nature*[1] we have reported experiments showing that impairment of the oxidative metabolism is a very early symptom in choline deficiency; and we concluded that choline is essential for intermediary metabolism, by being used in the formation of an unknown bio-catalyst or coenzyme. Later experiments have emphasized the specificity of choline; the curative effect cannot be produced by injections of methionine or methionine + ethanol amine.

In a series of communications[2–6] we have shown the presence of a new choline compound, the acetylcholine percursor, which is not only the immediate source of liberated acetylcholine, but most probably necessary also for purely muscular functions. We therefore tested the effects of an impure preparation of this substance on the metabolism of minced muscles from choline-deficient rats.

Ox spleen was extracted with ethyl alcohol, which was then concentrated *in vacuo*, washed with ether or petroleum ether, dissolved in water, and precipitated with acetone, as described in an earlier communication[7]. For the experiments we used albino rats, 28 days old, which were placed on the choline-deficient diet already described[1]. They were used for metabolism experiments on the fifth to seventh day on the test diet. Animals with renal hæmorrhages were not used, as uræmia itself slows down the decolorization of methylene blue, and is not influenced by injections of choline. This effect was checked by using normal animals after nephrectomy.




TIME (MIN.) REQUIRED FOR DECOLORIZATION OF METHYLENE BLUE *in vacuo*

*A*, CONTROLS; *B*, CHOLINE-DEFICIENT RATS

White columns represent the mean of two values on muscles only; black columns adjacent represent the mean of two values from the same muscles with addition of spleen extract corresponding to about 1 gm. of fresh spleen. In each Thunberg tube: 1·250 ϒ methylene blue, dissolved in 2·5 ml. of m./15 Sörensen phosphate buffer *p*H 7·15, and 0·2 gm. of minced muscles of hind limbs

As seen from the graph, addition of the spleen extract to the Thunberg tubes normalizes the impaired metabolism of minced muscles from choline-deficient rats, but it has practically no effect on muscles from control animals on the same diet plus 0·6 per cent of choline chloride. Thus, the disturbances in metabolism are prevented or cured by choline in the food or in injections, but choline has no effect *in vitro*; it must pass through the organism to be transformed into a bio-catalyst; the extract is effective *in vitro* and probably contains the complete catalyst.

It is not yet possible to decide if the active principle of the extract is identical with the acetylcholine precursor. We know that the precursor decreases in muscles of choline-deficient rats[6]; we know that the metabolic factor probably is a complex choline compound and that this factor and the precursor have the following characters in common: both are soluble in alcohol and in water but insoluble in ether and petroleum ether, both are precipitated from aqueous solution with acetone and barium salts, and both are destroyed when boiled with strong acids but are more stable in slightly acid solutions.

Barium salts added to a watery solution of the acetone powder produce a precipitate; after centrifugation the clear solution is inactive. We have, however, not been able to regain the metabolic factor from the barium precipitate. If a solution of the acetone powder in 2 *N* hydrochloric acid or in 1*N* sodium hydroxide is boiled for 15 minutes, cooled, neutralized and again precipitated with acetone, the precipitate has lost its metabolic activity. At *p*H 4 it can be boiled for 30 minutes without losing its activity.

Full reports are being published in *Acta Pharmacologica et Toxicologica*.

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## A New Unit in Photo-electric Colorimetry

The quantity $E^{1\ \text{per cent}}_{1\ \text{cm.}}$ does not always lend itself to be used in photo-electric colorimetry. As absorption is generally determined where strong bands occur, a 1 per cent solution in a layer of 1 cm. gives in most cases a reading far below the range of sensitivity of the instrument. Furthermore, it will be found that in many cases the Beer–Lambert law cannot be used for extrapolating from $E^{1\ \text{per cent}}_{1\ \text{cm.}}$ values those concentrations which cover the useful parts of the scale.

The use is, therefore, suggested in practical work of the 'half-value' of the substance, that is, the weight (in grams) of a substance which has to be contained in one ml. solvent in order to reduce the transmitted light by a half, the length of path being 1 cm., and the light transmitted by the solvent alone being unity. The proposed symbol for this quantity is $W^{50}_{1\ \text{cm.}}$.

Several advantages are claimed for this suggestion. First it should facilitate the reproduction of data obtained from a different instrument, as it refers to the most sensitive part of the scale; secondly, if, for example, in medical biochemistry, a test has been worked out so as to have its mean at a colorimeter reading of 50 per cent transmission, readings above and below this mean are, over a wide range, practically equally reliable. Often no allowance is made for the fact that the measured transmission depends on extraneous factors as well, such as colour-temperature of the filament, monochromaticity of the filter, and characteristics of the photo-cell. Thus it can be easily shown on a filter-colorimeter that the apparent transmission of a coloured fluid varies when the colour-temperature of the lamp is altered, as the filters are not strictly monochromatic. The steeper the slope of the absorption curve of a fluid, the greater this error will be. For example, solutions of potassium dichromate which exhibit strong absorption in the violet but pass red freely show this phenomenon for blue and green. The use of $W^{50}_{1\ \text{cm.}}$ can overcome part of these difficulties.

In practical work the half-value of a substance is quickly arrived at by taking two concentrations yielding transmissions above and below the half-value. From either concentration $W^{50}_{1\ \text{cm.}}$ is calculated, assuming that the solution obeys the Beer–Lambert law. Both estimates are now pooled. Then two new solutions are prepared, containing slightly more/less than the expected half-value; whence $W^{50}_{1\ \text{cm.}}$ is accurately found.

A worked example of this principle is set out below. Standardized hæmin (for which we wish to thank Prof. E. J. King) is treated with alkali[1]. Its $W^{50}_{1\ \text{cm.}}$ is found to be 0·000 039 4 gm./ml., when determined in a 'Lumetron' photo-electric colorimeter, using a monochromatic Corning glass filter with a peak at 515 mμ. The practical usefulness of such a statement may be greatly enhanced by stating $W^{50}_{1\ \text{cm.}}$ for potassium dichromate under identical conditions (in our case 0·00285 gm./ml.); for in the absence of the original material, the potassium dichromate may serve as a handy secondary standard. When both are available an additional check is afforded.

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## Digestibility of Cow's and Buffalo's Milk

The cow is the main animal for milk production in the world. In Africa, Asia and some parts of Europe, the buffalo is used as well as the cow to provide milk for human consumption. In Egypt, the statistics of the Ministry of Agriculture in 1937 record 956,036 buffaloes compared with 983,219 cows. The average composition of cow's and buffalo's milk in Egypt, as a result of a series of analyses of milk given by the Faculty of Agriculture herd for two consecutive years, was found to be as follows:

| | Density at 15° C. | Moisture % | Dried subst. % | Proteins % | Fats % | Ash % | Lactose % |
|---|---|---|---|---|---|---|---|
| Cow's milk | 1·0325 | 85·90 | 14·10 | 3·75 | 4·91 | 0·80 | 4·66 |
| Buffalo's milk | 1·0316 | 83·01 | 16·99 | 4·39 | 7·30 | 0·83 | 4·47 |

The composition differed mainly in the percentage amount of fat; whereas in cow's milk it was 4·91, it was 7·30 in buffalo's milk. This variation in the amount of fat raised the question whether the high amount of fat in buffalo's milk decreased the digestibility of the other constituents of milk. In Egypt, physicians, under the influence of this notion, have prescribed cow's milk in artificial lactation and clinical dietetics, as it was thought to be more digestible than buffalo's milk. It was therefore thought worth while to test the digestibility of cow's and buffalo's milk.

For this purpose, three sheep, one less and two more than one year old, were selected at the Experimental Station of Animal Nutrition of the Faculty. They were kept separately, each in a metabolism box. Before determining the digestibility of milk, a separate experiment was performed first on the same sheep to measure the digestibility of hay which would be given to supplement the milk. The same sheep then received a measured amount of milk supple-

mented with a weighed amount of hay. The experiment was divided into two periods: seven days as preliminary period and ten days as original one. The amount of hay and of milk given was just sufficient for maintenance. Cow's milk was used first, and then the experiment was repeated using buffalo's milk. The sample of milk given daily was prepared from the daily mixture of cow's or buffalo's milk collected from the Faculty's herd. A sample of milk as given to the sheep was taken daily, and its density and the percentage of dried matter, fats, proteins and lactose determined. Fæces were collected daily and dried in an oven at 70° C., and then ground at the end of the experiment and kept for analysis.

The final figures for the digestibility of the different constituents of both types of milk from the average figures obtained from the three sheep, with the exception of lactose (means of two sheep only), were as follows:

| Coefficient of digestibility of | Dry matter | Proteins | Fats | Lactose |
|---|---|---|---|---|
| | % | % | % | % |
| Cow's milk | 79·21 | 83·18 | 97·07 | 75·27 |
| Buffalo's milk | 77·04 | 83·87 | 97·62 | 74·78 |

From these results, it can be concluded that the digestibility coefficients of the different constituents of buffalo's milk are practically equal to those of cow's milk. As regards protein digestibility, we have verified this result in a separate experiment using pepsin and hydrochloric acid, when it was found to be 95·01 for cow's milk and 95·47 per cent for buffalo's milk. It seems, therefore, that the relative high amount of fat in buffalo's milk did not affect the digestibility of proteins and fats. The figures of the digestibility coefficients of lactose obtained in our experiment were low, although it is known that the digestibility is very high; this may be attributed to the bacteria present in the stomach of the ruminants. The idea of medical men that cow's milk is preferable to buffalo's milk, in our opinion, has no physiological basis.

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## Rancidity in Indian Butter Fat (Ghee)

Changes in analytical characteristics following upon the onset of rancidity in butters and butter-fats have been widely studied[1–6], with somewhat discrepant results. This is scarcely surprising in view of the number of variables involved, within the material itself and in the conditions of its spoilage. In the work here reported, the samples of ghee were prepared with some care and represent genuine products in good condition; the specimens examined were not chosen at random but belonged to three definite types—one, from Kirkee, of high Reichert value (30–40) and low iodine value (*c.* 28) typical of well-kept dairy buffaloes, another of normal Reichert value (*c.* 25) and iodine value (*c.* 38) from dairy cows, and the third of low Reichert value (14–22) and high iodine value (33–40) derived from buffaloes fed mainly on cotton-seed. The samples had all been stored in similar conditions, namely, in glass bottles with fairly loose-fitting wooden corks placed in a laboratory cupboard for periods of three to four years at a temperature range of 15–25° C. The analytical characteristics of the samples were determined before and after storage, and the average changes in each group were as below.

Changes in the analytical characteristics of ghees on storage

| | *A*. High Reichert value, low iodine value. (11 samples) | *B*. Normal Reichert value, normal iodine value. (12 samples) | *C*. Low Reichert value, high iodine value. (10 samples) |
|---|---|---|---|
| Acid value | +24·9 | +10·0 | + 18·2 |
| Peroxide ,, | +69·4 | +64·9 | +107·8 |
| Reichert ,, | + 4·3 | + 4·1 | + 3·9 |
| Polenske ,, | + 1·19 | + 0·93 | + 0·76 |
| Iodine ,, | −10·8 | − 8·3 | − 16·4 |
| Saponification value | +14·7 | +11·1 | + 13·6 |

In the three groups, changes in individual samples were all very similar to the average changes listed in the above table; while the parallelisms between the alterations in each characteristic suggest that they all proceed from a single general cause. Large increases in acid value (usually also associated with large increases in peroxide values) were almost invariably accompanied by large increases in Reichert, Polenske and saponification value, and, most significantly, by big falls in iodine value. The inverse relation between rise in acidity and loss in iodine value indicated oxidative rancidity as the dominant factor in the normal spoilage of butter-fat in the tropics; this inverse relationship is strikingly evident in the smooth curves obtained when acid values are plotted against iodine value losses.

In a further effort to investigate the course of spoilage, the individual specimens in each of the three groups were mixed and the free fatty acids separated, the characteristics of the rancid product and its neutral and acidic constituent fatty acids being then determined. The free acids from each group had high Reichert and Polenske and saponification values and very low iodine values (14–20). Lower acids had presumably been produced by oxidation of unsaturated acids, mainly oleic, rather than by lipolysis from lower fatty acid glycerides, since the Reichert and Polenske values of the de-acidified ghees closely resembled those of the original specimens when fresh (showing that these glycerides had largely remained intact). The low iodine values contrasted with the high figures obtained for the free fatty acids from rancid butter by Davies[7], and again pointed to a mainly oxidative mechanism producing free acidity in butter-fat as opposed to a lipolytic one (somewhat selective towards oleic glycerides) in butter.

Work is in progress here on the more exact nature of the free fatty acids, an account of which will be published later. The work above reported was carried out at the Department of Biochemistry, Indian Institute of Science, Bangalore, India, and grateful acknowledgment to Mr. B. N. Banerjee and Prof. V. Subrahmanyam is made for their interest in its progress.

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# RESPIRATION OF DEVELOPING ANTHERS

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UNDER greenhouse conditions the growth in length of flower buds of *Lilium longiflorum* is exponential over the period of about five weeks preceding anthesis, during which they elongate from about 10 mm. to about 155 mm. Blackman's[1] formula can be fitted satisfactorily to the growth curves, if length is substituted for weight ($L_t = L_0 e^{rt}$). Hence, the length of a bud may be taken as an index of its age, and logarithms of bud-lengths may be used in lieu of time in describing the development of the bud. For example, the average value of $r$, in the terms of this formula, for twenty-six buds the lengths of which were recorded each day from February 11 to April 8, 1946, at greenhouse temperatures fluctuating between average daily limits of 16° C. and 27° C., is 0·0765. At this daily 'interest' rate, a bud would grow in length from 10 mm. to 100 mm. in 30·1 days. Dividing the distance from 10 mm. to 100 mm. on a logarithmic scale of bud-lengths into thirty equal parts produces a linear scale of days.

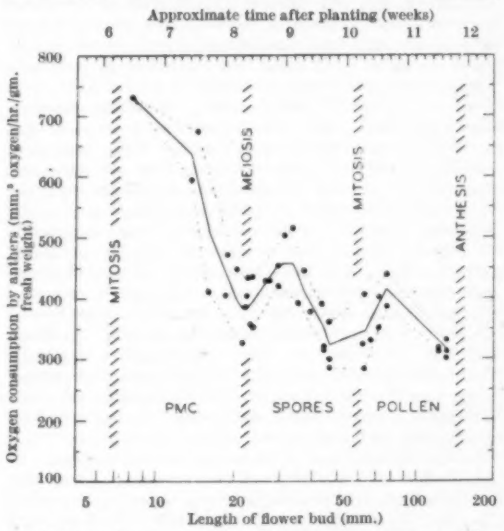
In the development of pollen within the anther, four significant events are: (1) mitotic division of the archesporial cells, which yields sporogenous cells, later microsporocytes; (2) the meiotic divisions of the microsporocytes (pollen mother cells), which yield quartets of microspores; (3) mitosis of the microspore nuclei, which yields binucleate pollen grains; and (4) anthesis, which leads to dehiscence of the anthers and release of the pollen. These four events have been located at the appropriate points on the accompanying figure, on the basis of microscopic examinations of the contents of anthers from buds of known length. The time interval, when $r = 0{\cdot}0765$, between (1) and (2) is about fifteen days; between (2) and (3), about thirteen days; and between (3) and (4), about twelve days. Detailed data supporting these statements will be presented elsewhere.

For all the microsporocytes, microspores or pollen grains within the six anthers of a bud, these nuclear events are much more closely synchronized than in the case of the cells of most other growing organs; for example, a root tip. Since the anther presents at a given time a large number of cells in the same phase of mitotic or meiotic division, it is a favourable object for investigating possible correlations between cytological and physiological processes. Preliminary evidence of one such correlation is reported below.

The respiratory rates of excised whole anthers of *Lilium longiflorum*, from flower buds of various lengths, have been determined at 25° C., in Fenn[2] microrespirometers. Each respirometer vessel contained from one to six anthers, depending on their weight. The anthers were not submerged, nor were the vessels shaken. Readings of oxygen uptake were continued, in most cases, for three hours after dissection of the buds. Determinations of the rate in oxygen, nitrogen, and mixtures of these gases showed that respiration of the anthers was not limited by oxygen tension at tensions greater than one fifth of that in the atmosphere. Rates in air were reasonably constant during the three hours over which most of the determinations extended.

The respiratory rate in air for each sample of one or more anthers, usually during the first hour after dissection, has been plotted in the figure against the length of the bud. A time-scale of days and weeks has been superimposed on that of bud-lengths. The limits within which all the data lie are indicated by broken lines, and the solid line has been drawn midway between these extremes.

The youngest anthers, from a bud 8·1 mm. long, were essentially meristematic in character and respired at the rate of 731 mm.³ of oxygen/hr./gm. fresh weight. As the anther differentiates and approaches maturity, there is a general decline in its respiration to less than one half of the original rate. The three oldest anthers studied, from a bud 132·4 mm. long, about two days before anthesis, respired at the average rate of 314 mm.³ of oxygen/hr./gm. fresh weight. Such a decline in respiratory intensity is a usual concomitant of development and maturation of plant organs. But superimposed on this decline are two fluctuations which coincide with the meiotic divisions of the microsporocytes, and with mitosis of the microspore nuclei, respectively. Each of these fluctuations consists of a fall below the prevailing




respiratory level, and a subsequent recovery. The presumption is that the two fluctuations reflect temporary diminutions, or even cessations, of respiration of the microsporocytes and microspores as they divide. One would expect fluctuations in the respiration of these cells to be damped by the presence of the anther wall and tapetum. It would be desirable, therefore, to determine the respiratory rates of isolated microsporocytes, microspores and pollen.

H. Stern[3] has observed a pronounced increase in permeability of microsporocytes of *Trillium* during meiosis. There is evidence in his data and in those presented here that the division of a cell entails a profound departure from its metabolism during the interphase. Since most studies of the metabolism of growing tissues necessarily integrate the behaviour of many cells at various stages of division, a disturbance of the physiology of single cells during division would not ordinarily be apparent. Further exploration of the possibilities inherent in this study of the physiology of developing anthers may prove

to be a profitable means of increasing our understanding of the mechanism of cell division in general, and of the unusual character of the meiotic divisions in particular.

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# NATIONAL RESEARCH COUNCIL OF CANADA

## ANNUAL REPORT

THE twenty-ninth annual report of the National Research Council of Canada, 1945–46 (Pp. 65. From the offices of the Council, Ottawa), includes the report of the President, together with reports of the Directors of Divisions, the financial statement and details of scholarships awarded. Among the outstanding developments in 1945–46 mentioned in the President's report are the investigations relating to atomic energy, the release of information on radar research, the design and construction of a plywood tailless aircraft and the development to the pilot-plant stage of a process for butylene glycol from wheat. Gauge inspection work was brought to a close in September 1945, and a building research conference laid plans for co-ordinating studies and initiating practical schemes for the improvement of housing in all its branches, including construction, plumbing, heating, ventilation, lighting and the planning of housing projects with regard to their economic and social aspects. Much work undertaken for the Services as a war measure will be continued in peace-time, but with industrial and commercial applications; for example, applications of radar as aids to air and sea navigation, medical researches on the control of infectious diseases, studies on shock and blood substitutes, the development of plastic prostheses for artificial limbs, studies on heat-retaining properties of textiles used in clothing, shrink resistance of woollens, particularly socks, and wearing qualities of leathers and leather substitutes used in boots.

In the laboratories at Ottawa, the reconversion to peace-time applications of war research and the initiation of new problems are proceeding rapidly; the staff now numbers about 1,400, of whom one half are of professional grade. Through pilot-plant operations, the Structures Laboratory has gained much valuable experience in the use of synthetic resin adhesives, plywood moulding techniques, the application of glueing pressures to complicated assemblies and on the advantages and deficiencies of various glue-lime heating methods and similar problems. A recent inquiry concerning the Kingsville Harbour on Lake Erie handled by the Hydrodynamics Laboratory, in which an alternative was sought to the annual dredging necessary to maintain the navigational channel between the parallel piers protecting the harbour, involved construction of a miniature replica of the harbour and simulation of the conditions affecting the formation of the sand-bar before proposals for the extension of the longer pier could be formulated. Work is also in progress on another model dealing with the formation of sand-bars in the Fraser River.

In the Physics Laboratory, a main objective of work in radiology has been to develop new and improved instruments for the location of radioactive ores and the measurement of such ores and their products. New techniques have been developed for X-ray and radium radiography, and other investigations have dealt with the use of X-ray diffraction and electron microscopy in the examination of catalysts, pigments, rubber-compounding ingredients and other industrial materials. High-voltage research is being continued, and studies are being made of recently developed insulating materials, as well as of improved safety codes, new methods of house wiring and problems of rural electrification. Special electrical problems of the Chalk River atomic energy project are now demanding the attention of the Laboratory, while the Chemical Engineering Section of the Applied Chemistry Branch of the Division of Chemistry is giving attention to the design of the water-treatment plant for the same project as well as to the design of pilot-plant and full-scale plant for the extraction of fissile materials. The echo method of submarine detection is being investigated for its possible use in prospecting and in the detection of flaws in solid structures, while possible industrial uses of high-intensity and high-frequency sound are also being considered. Special investigations in physical oceanography initiated during the War are being continued in collaboration with other Government departments and the Canadian marine industry. A new method of heating houses by floor or ceiling radiant heat panels is being developed, and the effect of window ventilation in severe weather if floors are heated is under examination. Part of the investigation is concerned with the measurement of moisture in wheat and the speed of transference of this moisture from one part of the stored wheat to another, a problem which bears directly on the preservation of wheat from mites.

The Division of Chemistry has now been divided into a Fundamental Branch and an Applied Chemistry Branch; when the new chemical engineering building in the latter Branch has been completed there will be provision for at least three pilot-plants. Industrial researches in progress include work on laundering and cleaning, and interesting results have been obtained on the use and action of detergents and on soil-removal problems. The preservation of fabrics against rot, use of organic rust inhibitors in metal priming paints, silver catalysts for the oxidation of ethylene to ethylene oxide, synthesis of organic compounds containing heavy hydrogen, the chemistry of acetylene, use of acetylene black in rubber compounding, the testing of leather products and plastics and a study of methods for determining carbon monoxide in low concentrations are among other investigations of the Applied Chemistry Branch. About a third of the work of the Division has been concerned with fundamental problems in organic chemistry, including alkaloid studies and synthesis, the kinetics of polymerization and the synthesis of methoxybutadiene, photochemistry, including mercury-photosensitized and other reactions of unsaturated compounds, surface chemistry, such as the electrical resistance and length-changes of activated carbon rods, and studies on macromolecules, and colloid chemistry, including the development of a new and simple film balance which is being used to investigate the properties of gaseous films of fatty acids.

In the Division of Applied Biology, the utilization of agricultural surpluses and wastes, and food investigations have been the two main fields of

activity. Two new fermentations studied in the laboratory capable of giving high yields of butylene glycol, with glycerol or formic acid as secondary products, are ready for pilot-plant study. Cyclic methyl ethyl ketal, derived from butylene glycol, shows promise as a blending agent for motor fuels, and aqueous solutions of *l*-butylene glycol appear to be satisfactory anti-freeze substances. A method of separating starch from gluten has been developed, and investigations commenced on the manufacture of wheat syrup. Food investigations during the War were directed almost entirely to the problems involved in the transport of perishable goods to Great Britain, work on egg products being particularly important. Quality-testing methods for use on canned poultry were revised, and it is expected that a plant based on the investigations on Irish moss as a substitute for the agar used in canned meats will shortly come into operation. Many nutritional problems were studied during the War at the request of the Armed Services. Co-operative studies with the Ontario Research Foundation and the Associate Committee on Grain Research were continued on the processing and treatment of domestic oils for edible purposes, and it was found that isolinoleic acid is not the only cause of flavour reversion in linseed oil shortenings. These studies are being continued in an effort to find means of preventing such reversion.

## ARTIFICIAL CULTURES IN THE CHICK EMBRYO

"CULTIVATION of Viruses and Rickettsiæ in the Chick Embryo", by W. I. B. Beveridge and F. M. Burnet (*Med. Res. Coun. Spec. Rep. Ser.*, No. 256, 1946. H.M. Stationery Office, 2*s.* net), is a successor to a previous monograph by Dr. F. M. Burnet published in 1936. The method of growing viruses in the chorioallantoic membranes of the fertile hen's egg was at that time only just beginning. The pioneers of this method have been Burnet in Australia, where so much of this kind of work has been done, and Goodpasture in the United States. The development of the method has been so remarkable that the original technique of inoculating the chorioallantoic membrane is now supplemented by inoculation of the allantoic or amniotic cavities, of the yolk sac, of the veins of the membranes and even of some organs of the embryo itself.

In the present report these techniques are described and the particular difficulties of each are discussed. Important, too, are the notes on appearances in the egg which may be mistaken for lesions produced by viruses, and on bacterial contaminants which occur in some eggs. Useful also are the photographs and diagrams. The advantages of this technique for certain purposes include avoidance of the expense and time involved in the maintenance of small animals, the virtual elimination of cross-infection and the fact that the method gives greater yields of some viruses than can be obtained from any other source. Hen's egg is used, for example, for the production of typhus vaccines, and it can provide enormous yields of influenza virus. The method is also used for the preparation of vaccines against yellow fever and equine encephalomyelitis. A bacteriologically sterile vaccine against smallpox can be made using hen's eggs, but this method has not been widely used. Fertile eggs are also used as sources of certain diagnostic agents, such as Frei antigen, and the reagents needed for Hirst's hæmagglutinin reactions which can be used for the quantitative study of influenza viruses and their antisera.

Dr. Burnet is now director of the Walter and Eliza Hall Institute, Melbourne, where he has worked with Dr. Beveridge and others. This is surely a striking instance of the value in this field of collaboration of a medical man and a veterinarian. Everyone who works with viruses will find this report indispensable. Its thirteen pages of references to work on every aspect of this technique and its uses are by themselves worth more than the very moderate price charged for the whole monograph.

## UNIVERSITY LIBRARY SERVICE IN SOUTH AFRICA

THE inaugural address "The University Library, its Function and Potentialities", delivered by Dr. H. Coblans, librarian of Natal University College, Durban, on September 2, 1946 (Pp. 16. Durban: Natal University College), surveys the university library rather from the technical point of view of the librarian himself than from the wider angle of Bruce Truscot in "Red Brick University", and as he is also largely concerned with conditions in South Africa his address may disappoint some whom its title attracts. Dr. Coblans emphasizes the necessity of co-operation and co-ordination in scientific bibliographic service, and looks to the United Nations Educational, Scientific and Cultural Organisation for developments in that direction, urging incidentally the establishment in South Africa of at least one national centre corresponding with the Science Library in London. He recognizes that inclusive documentation may involve radical changes in existing bibliographical methods; but for the research worker, the technologist and the administrator, he considers the key tool should still be the abstract journal.

Dr. Coblans urges the development in South Africa of an inter-library loan system on the lines of that of the National Central Library in Britain, and the development of the essential Union Catalogue as well as the completion of Freer's "Catalogue of Union Periodicals". Directories of library resources, including special collections in industrial laboratories, a greater measure of co-operation at the level of uniform library techniques and standardization, the allocation of subject fields for intensive specialization by particular libraries, the use of microfilm to eliminate some of the huge gaps in South African holdings of scientific and technical periodicals, and to rescue important Africana in a state of rapid deterioration are among his concrete suggestions for improving bibliographic conditions in South Africa. Government support or subsidy and central organisation are also needed. The Council for Education, Sociological and Humanistic Research formed early last year has among its objects the promotion of library services and the provision of information services as well as assistance in the publication of results and other materials likely to be valuable for research.

Dr. Coblans then proceeds to discuss the informative rather than the distributive functions of the university, its work not merely in providing research materials for the scholar but also in bringing know-

ledge to the service of industry, municipal planning, health and social services. He regards it as the university librarian's task to provide the bibliographies needed, to guide inquirers to the best sources, to integrate and correlate the material. The librarian must know where and how to look, and much higher standards of education and of subject-specialization are accordingly demanded in library staff, while provision of the specialized information equally demands adequate provision of library tools in the way of catalogues, classification schemes and the like. Dr. Coblans sees, too, the library as an integrating influence, seeking to overcome departmental exclusiveness and over-specialization; and in recognizing the educational value of the new mediums such as films, he refers pointedly to factors which have obstructed the use of educational films in South Africa.

In conclusion, returning to the gaps in South African records and bibliographical tools, Dr. Coblans pleads for more comprehensive subject indexes to South African periodicals, newspapers and Government publications, for regular abstracts of research papers published in South Africa, for a register of all South African learned and technical societies and a directory of special collections; and he suggests that the four libraries in Natal University College should form a unit for bibliographical and information service to the province of Natal and the eastern seaboard and ultimately develop a university press.

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